PALLEN (M.A.)

PRIZE ESSAY.

VISION, AND SOME OF ITS ANOMALIES,

AS REVEALED BY

THE OPHTHALMOSCOPE.

BY

MONTROSE A. PALLEN, M.D.,

OF ST. LOUIS, MISSOURI.

Dux hominum medicus est.

EXTRACTED FROM THE

TRANSACTIONS OF THE AMERICAN MEDICAL ASSOCIATION.

PHILADELPHIA:

COLLINS, PRINTER, 705 LODGE ALLEY.

1858.

To my oldest and
best friend
Prof: M L Linton.
with sincere and affectionate
regards of the
Author.

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TO

JOHN H. WATTERS, A.M., M.D.,

PROFESSOR OF PHYSIOLOGY AND MEDICAL JURISPRUDENCE IN THE SAINT LOUIS MEDICAL COLLEGE.

SAINT LOUIS, May 19, 1858.

DEAR DOCTOR:

Accept this, the first dedication I have ever proffered, as an humble acknowledgment of your disinterested and self-sacrificing friendship, and as a recognition of your untiring zeal for the promotion of science.

Sincerely yours,

MONTROSE A. PALLEN.

PRIZE ESSAY.

VISION, AND SOME OF ITS ANOMALIES, AS REVEALED BY THE OPHTHALMOSCOPE.

THE following essay purports to consider two subjects, which are intimately connected: viz., the anatomy and physiology of the parts concerned in vision, and some of the derangements attending it. For the purpose of better illustrating these latter, the late discoveries effected by the ophthalmoscope will be entertained.

That branch of science which treats of the nature and laws of vision, is called optics, and is generally considered in three points of view, viz:—

A. *Perspective Vision*, which treats of the apparent size of objects, from the theory of the laws of the straight lined motion of light.

B. *Catoptric Vision*, which embodies the laws of the reflection of light, embracing always the principle, that the angle of incidence is equal to that of reflection.

C. *Dioptric Vision*, signifying the power of seeing through transparent media, involving the laws of refraction, which embraces the principle of the bending of light as it passes from a rarer to a denser medium, or *vice versâ.*

The two former have so slight a connection with our task, that it is needless to discuss the formulæ involving their demonstration. But as the third division enters very materially into the explanation of the *modus operandi* of vision, it is deemed advisable to enter into its discussion, when, further on, the subject will be brought up in its proper place.

The eye is the most complete of all optical apparatus, and, although it is perfected in man, he is not the sole possessor of

this "window of the soul," for many of the lower animals, the invertebrata as well as the vertebrata, are endowed with the sense of vision.

As we propose to take a rapid and cursory glance of the optical apparatus of the invertebrates, it may not be amiss or foreign to the subject, to sketch the various groups of the invertebrates, with regard to the structure of the visual apparatus. The vertebrate mammals are represented by man, whose eye will be more fully described, both as regards its anatomy and its physiology.

Before entering into any details concerning the invertebrata, we will give Siebold and Stannius'[1]

CLASSIFICATION OF THE INVERTEBRATE ANIMALS.

The invertebrate animals are organized after various types, the limits of which are not always clearly defined. There is, therefore, a greater number of classes among them than among the vertebrates. But, as the details of their organization are but yet imperfectly known, they have not been classified in a natural manner.

There are among them many intermediate forms, which make it difficult to decide upon the exact limits of various groups. The following division, however, from the lowest to the highest forms of organization, appears at present the best.

ANIMALIA INVERTEBRATA.

INVERTEBRATE ANIMALS.

Brain, spinal cord, and vertebrate column, absent.

First Group.—PROTOZOA.

Animals in which the different systems of organs are not distinctly separated, and whose irregular form and simple organization are reducible to the type of a cell.

Class I. *Infusoria.*
" II. *Rhizopoda.*

Second Group.—ZOOPHYTA.

Animals of regular form, and whose organs are arranged in a ray-like manner around a centre, or a longitudinal axis; the cen-

[1] Anatomy of the Invertebrata, by C. Th. v. Siebold. Translated from the German by Waldo I. Burnett, M. D.

tral masses of the nervous system forming a ring, which encircles the œsophagus.

Class III. *Polypi.*
" IV. *Acalephæ.*
" V. *Echinodermata.*

Third Group.—VERMES.

Animals with an elongated symmetrical body, and whose organs are arranged along a longitudinal axis; so that right and left, dorsal and ventral aspects may be indicated. The central nervous mass consists of a cervical ganglion, with or without a chain of abdominal ganglia.

Class VI. *Helminthes.*
" VII. *Turbellarii.*
" VIII. *Rotatorii.*
" IX. *Annulati.*

Fourth Group.—MOLLUSCA.

Animals of varied form, and whose bodies are surrounded by a fleshy mantle. The central nervous mass consists of ganglia, some of which surround the œsophagus, and others, connected by nervous filaments, are scattered through the body.

Class X. *Acephala.*
" XI. *Cephalophora.*
" XII. *Cephalopoda.*

Fifth Group.—ARTHROPODA.

Animals having a perfectly symmetrical form and articulated organ of locomotion. The central masses of the nervous system of a ring of ganglia surrounding the œsophagus, from which proceeds a chain of abdominal ganglia.

Class XIII. *Crustacea.*
" XIV. *Arachnida.*
" XV. *Insecta.*

Having premised the above classification, we propose to enter upon the visional apparatus of the Invertebrata, and will begin with the *Protozoa.*

Most of the *Infusoria* and *Rhizopoda* have simple red pigment spots, capable only of distinguishing light from darkness, and

which, without a special optical apparatus, accomplish the object by the whole surface of the body. Ehrenberg[1] presumed the pigment spot to be an eye, but it has no connection with a nervous spot or expansion, and contains no refractive media.

Of the second group (the *Zoophytes*), but few of the *Polypi* have organs of vision: their sensibility to light is perceived by the whole body. The *Syncoryne* and *Coryne*[2] have four red organs corresponding to ocular globes; and, the organ seen at the base of the six arms of the *Eleutheria dichotoma*, contains refractive media, viz., the cornea, crystalline lens, and aqueous humor.

Of the *Acalephæ*, the *Ceniphora*[3] is the only order having an organ corresponding to the eye: the organ in question has been considered by many as also performing the functions of audition.

Of the *Echinodermata*[4] there are none which possess an eye.

Of the third group, or *Vermes*, the *Helminthes*[5] possess no eye: the *Turbellaria*[6] have on the anterior extremity a light refracting body, containing a cornea, which corresponds to an eye: the *Rotatorii*[7] have single or double eye-specks upon the neck, and sometimes upon the forehead: these specks are covered by a cornea, and are situated upon the cerebral ganglion, and also connected with it by nervous filaments. The *Annulati*[8] are without eye-specks. Among the *Acalephæ*, an order of the fourth group, organs of vision are very common, and occupy a large portion of the borders of the mantle, or are situated upon the external orifices of the longer or shorter mantle-tubes. These eyes contain a cornea, aqueous humor, sclerotica, greenish or bluish iris, and retina. Most of the *Cephalophora*[9] possess organs of vision, and are seldom more than two in number. These eyes contain a cornea, sclerotica, iris, choroid, retina, and optic nerve.

The *Cephalopoda*[10] have very highly developed eyes which are disproportionately large: they are quite similar to those of the vertebrata. These eyes are composed of a cornea, aqueous humor, iris,

[1] Abhand'l. d. Berliner Akad., 1831, p. 12; also, Die Infusionthierchen, p. 491.
[2] Dumortier, Mém. sur. l'Anat. et la Physiol. d. Polypiers, p. 41.
[3] Milne-Edwards, Annal. d. Sc. Nat., pp. 206, 211.
[4] Valentin, Monograph. Zoophyta, p. 198.
[5] Müller, Zool. Danica., tab. LVIII. figs. 16, 17.
[6] Siebold, Anat. of Invertebrat., loc. cit., p. 135.
[7] Ehrenberg, loc. cit., and Siebold, loc. cit., p. 145.
[8] Cuvier, Mém. sur les Thalides, p. 12.
[9] Swammerdamm, Bibel der Nat., p. 47, tab. IV. figs. 5, 8.
[10] Mayer, Analekt, f. vergleich. Anat. Hft. i. p. 52.

crystalline lens, vitreous body, choroid, retina and optic nerve. Among those of the fifth group, or the *Anthropodia*, the Crustacea[1] most generally possess eyes, which exist in various grades of development. One form of these eyes, which is the lowest order, is known as *Simple;* they are composed of a cornea anterior to a refracting lens, surrounded by a layer of brown, blue, red or black pigment; at the most convex point of the lens, the optic nerve penetrates. Another form of these eyes is the *Compound Unfaceted*,[2] which consist of numerous eyes covered by a common cornea. Still another form is the *Compound Faceted*,[3] which is composed of very numerous tetragonal or hexagonal facets, behind each of which is a conical or prismatic lens, fitted in the vitreous body, and connected with a filament of the optic nerve. The Arachnoidæ[4] always possess simple eyes (stemmata), which are analogous to the simple eyes of the crustacea. They are formed of a cornea, lens and vitreous body surrounded by a retina, which is enveloped by a pigmentary membrane corresponding to the choroid. The Insecta[5] possess simple and compound eyes. The simple eyes (Ocelli, Stemmata) are composed of a cornea, either convex, elliptical, or spheroidal, a spherical or cylindrical lens, a pigmentary membrane corresponding to the choroid, and an optic nerve. These simple eyes are sometimes situated so contiguous to the brain, that the optic nerve is but a mere scale. The compound eye[6] is composed of single eyes whose corneæ are quadrangular or hexagonal, all of which are covered by one common faceted cornea. Behind each cornea, instead of a lens, there is a transparent pyramid whose apex is directed inwards, and received into a cup-shaped body corresponding to the vitreous humor, which is again enveloped by an expansion of the optic nerve, constituting the retina. Each pyramidal lens is enveloped by its own choroid.

As regards the differences in the Anatomy of the eyes of Vertebrate mammals, their general forms are so slightly varied from that of man, that a mere glance at some of the peculiarities will suffice.

[1] Müller, Zur vergleich. Physiol. d. Gesichtsinnes, p. 307.
[2] Tiedemann, Zeitsch. f. Physiol., p. 97.
[3] Milne-Edwards, Hist. Crust., t. i. p. 117.
[4] Latreille, Règne animale, iv. p. 207, 1829.
[5] Marcel de Serres, Mém. sur les Yeux comp. et les Yeux lisses d'Ins.
[6] Will, Beiträg. zur anat. d. zusammengesetzen augen mit facettirt, Hornhaut, 1840.

With carnivorous mammals, one of the most remarkable additions to the eye, is a strong retractor muscle, shaped like a hollow cone, with its apex attached to the bottom of the orbit, and with its marginal base inserted into the sclerotic, which it embraces, being under the recti muscles. Its use is to draw the eye within the orbit, giving it a very peculiar expression of hollowness, observed in the carnivora when enraged.

With birds and fishes there exist some peculiarities which we will cursorily notice. Fish are unprovided with eyelids; and, there is but little independent motion of the ball. Near the optic nerve between the layers of the choroid, is a gelatinous red structure, denominated the *choroid gland*, the use of which is unknown. Fish most generally are devoid of ciliary processes and bodies; but there is a rudimentary structure very similar to the ciliary bodies and corresponding to the pecten of birds.

With regard to birds, a sketch of the optic apparatus of the common owl (*strix bubo*) will explain the pecten, and the curious mechanism of the third eyelid, or *membrana nictitans*. The general shape of the eye is that of a bell, which arises from the disposition of a series of quadrangular osseous plates, convex on their inner aspect, which overlap, and are accurately fitted to each other. The firmness and rigidity thus communicated to the exterior casing containing the refractive media, prevent their pressure throwing the eye into a globular form. The ciliary body extends over the whole of this portion of the surface. The pecten is a curious quadrangular fold of the choroid, which projects into the vitreous body (in some birds it is attached to the lens), and is rather short and folded upon itself, very similar to a lady's fan. Its use is as yet a mooted question. The yellow spot of Sœmmering in the human retina is a rudiment of the pecten.

At the back of the globe, two muscles, originating from the sclerotica, are curved superiorly and inferiorly around the optic nerve. The superior and larger, the *Quadratus*, is attached near the margin of the sclerotic, its fibres converging to a narrow tendon, perforated through its whole length like the hem of an apron. The inferior and smaller muscle, from its shape called the *Pyramidalis*, is inserted in an opposite part of the circumference; its fibres converge and are attached to a long round tendon, which passes through the *hem* or loops of the Quadratus, thence turning over the edge of the broad part of the sclerotic, is continued over the bell-shaped surface, where it passes through several filiform loops

or pulleys, which keep it applied to the concavity, and around a bony projection from the surface.

It is attached near the cornea, to the membrana nictitans, an elastic fold of the conjunctiva, which constitutes the third or winking eyelid. From the *modus operandi* of these muscles, the sweeping action of the membrane is readily understood, as it is moved with incredible rapidity over the ball, and as rapidly rebounds owing to the elasticity of its structure. The membrane is of a milky hue, and has for an object the cleansing of the ball from hypersecretions and foreign substances. The haw of quadrupeds is the analogue of the membrana nictitans; this *haw* is frequently forced out of the orbit toward the inner canthus, by the pressure of the globe upon it, as it is unprovided with muscles. In the human eye there is a rudimentary winking membrane, which is a small crescentic fold of conjunctiva situated at the inner canthus behind the lachrymal caruncle.

Having thus cursorily glanced at the Invertebrata, as well as a few of the Vertebrata, with regard to the optical apparatus, we will, according to the proposed plan, sketch the Anatomy of Vision as it is typified in Man, the highest of mammals, by remarking the details of structure of the ocular globe proper.

The eye, as seen in man, is composed of four distinct parts.

I. The wall or tunics, constituting the protective parts.
II. The adjunct portions for its perfection as an optical instrument.
III. The dioptric apparatus or refractive media.
IV. The visional or specially sensitive parts. The protective parts of the apparatus are the Sclerotic and the Cornea.

The sclerotic is a strong, fibrous, dense and white membrane, thicker posteriorly than anteriorly, where it presents the appearance of a truncated sphere of one-fifth, and has a bevelled edge for the reception of the cornea in a manner very similar to the fitting of a watch crystal in its case. Posteriorly, and a little to the internal side of the axis of the ball, it is perforated by the optic nerve. No nerves have as yet been traced into its substance, although many, together with bloodvessels, pass through it. The outer surface is rough and firm for the attachment of muscles, but everywhere else is perfectly smooth; the inner surface is of a light brown color, and roughened from the presence of the *membrana fusca*, a delicate areolar membrane through which branches of the ciliary

nerves and vessels pass in an oblique manner. The texture of the sclerotic is similar to that of tendon, viz., of longitudinal and transverse fibres interlaced at right angles with each other. The cornea, which is one of the dioptric media as well as a protective part of the eye, is circular, occupying the anterior fifth of the eye, and resembling the segment of a smaller sphere adapted to a larger one. Its anterior border surface is convex, and its posterior one concave. The cornea has properly but one layer; all others mentioned by anatomists, being produced by boiling water and other re-agents acting upon its chondrin. Bloodvessels do not exist in the cornea proper, its nutrition being carried on by endosmosis and exosmosis; its structure is of stratified bundles of fibres, analogous to those of the areolar tissue, and between which, there exists an amorphous, solid, and transparent matter. Anterior to the cornea is the conjunctiva, erroneously presumed by some to be the first layer of the cornea; it consists simply of stratified tessellated epithelium, and is continuous with the conjunctiva scleroticæ, and wants only its cellulo-vascular basis. Behind the cornea is a very solid amorphous membrane, covered by a pavement epithelium which is called the membrane of Demours or Descemet, a continuation of which is carried over the iris. Schlemm has traced branches from the ciliary nerves into this membrane.

The adjunct parts for the perfection of the eye, as an optical instrument, are: the Iris, which serves as a diaphragm, to prevent the passage of too much light, and to correct the aberration of sphericity; the Pigment, which serves for the absorption of light, and the Choroid, which is but a continuation backwards of the iris.

The Iris is a disk or circular membrane placed behind the cornea, and anterior to the crystalline lens, dividing what are called the chambers of the eye into two unequal portions, the *anterior* being larger than the *posterior*. The pupil is a circular opening or perforation, situated rather to the inner and upper part of the iris; it presents a free border, known as the *pupillary margin*. The anterior face of the iris, carpeted by the same epithelium as that of the membrane of Descemet, presents a number of radiating fibres, of a streaked whitish tendinous character; they diverge from or converge to the pupil at about $\frac{1}{30}$ of an English inch from the pupillary margin, constituting what is known as the *larger* or *outer* ring, between which, however, and the pupillary margin they are concentrically arranged, constituting the *smaller* or *inner* ring. The fibres of the rings are non-striated muscular, and by their contrac-

tion produce the changes in the size of the pupil; the outer ones contracting producing *dilatation*, whereas the inner ones doing likewise, produce *contraction*. The posterior border of the iris is covered by the *uvea*, or an aggregation of pigment granules with nuclei and without cell-walls. This side of the iris, unlike the anterior, wants epithelium, and is continuous with the choroid, by the *annulus albidus* or *ciliary ligament*, or more properly the *tensor* or *circular muscle* of the choroid, which has been proven by Brüke to be of the non-striated class of muscles; but of this when we speak of the choroid. The iris is very abundantly supplied with bloodvessels and nerves. The arteries are the long posterior ciliaries, branches from the short posterior ciliaries, ramifying in the ciliary processes, and branches from the anterior ciliaries. There are veins which run parallel or correspond to the posterior ciliaries (arteries), whilst the veins corresponding to the anterior ciliaries, communicate with the *sinus circularis iridis*, or canal of Fontana, which is lodged in a groove parallel to the junction of the inner surface of the sclerotica with the cornea, where the ciliary ligament is inserted, and is of sufficient size to permit the passage of a hair within its calibre. The different bloodvessels form a very free anastomosis at the circumference of the iris, whence branches proceed to the pupillary margin, near which another finer vascular network is formed, whence capillary loops go to the pupillary margin. The long posterior ciliaries enter the sclerotic at a greater distance from the optic nerve than do the short ones, and then proceed in a line corresponding to the equator of the eye, upon the outer surface of the choroid, on the nasal and temporal sides, where about $\frac{1}{4}$ of an inch from the ciliary processes of the iris upon the temporal side, less upon the nasal, they divide at a very acute angle into the upper and lower branches. They all inosculate in the *annulus albidus*, whence their ramifications extend to the above described, first vascular circle. The ciliary nerves or nerves of the iris, from twelve to fifteen in number, arise from the nasal branch of the fifth pair, and especially the anterior portion of the ophthalmic ganglion, unite into two bundles, pierce the sclerotic near the entrance of the optic nerve, and pass forward on the outside of the choroid, to be distributed to the tensor muscle of the choroid, or annulus albidus, whence they ramify in the muscular fibres of the iris. The fibrillæ of the ciliary nerves, which preside over the *circular muscle* of the iris, arise from the third nerve, whilst those governing the radiating muscle, come from the spinal and the sympathetic of the neck.

The functions of the iris are to measure the quantity of luminous rays necessary to vision: for in a glare of light the pupil is contracted, and in obscurity it is dilated; undoubtedly showing that these functions are governed by the reflex-motor and automatic system of nerves. The iris also serves to correct the aberration of sphericity. The color of the iris depends upon pigment cells deposited in front and behind the membrane, and the presence of pigment deposits within its substance. The *uvea* is a quantity of pigment contained under a thin transparent membrane covering the posterior face of the iris; and, as its quantity is increased so is the tint deepened. The pigment cells of the iris as well as of the choroid are for the most part polyhedral in figure, generally hexagonal, and joined together like Mosaic work; others are spheroidal, particularly those of the uvea: in Albinos they contain no colored granules. The contents of these cells are minute brown or black granules, either spheroidal or elliptical, measuring in their greatest diameter from $\frac{1}{17000}$ to $\frac{1}{24000}$ of an inch, and after having escaped from the cell-membrane, they exhibit a peculiar molecular movement. Chemically this black or brown matter is insoluble either in hot or cold water, alcohol, acetic or diluted mineral acids, fixed or volatile oils. Oxide of iron, chloride of sodium, lime and its phosphates are obtainable from its ashes.

The function of the pigment is evidently and obviously intended to absorb redundant light, hence Albinos bear but indifferently well the superabundance of light, and see better at night than during the daytime.

The choroid is a very delicate membrane which carpets the posterior portion of the eye, and lies between the sclerotic and retina. Penetrated posteriorly by the optic nerve it extends thence to the *tensor muscle* or *annulus albidus*, and to the anterior portion of the hyaloid membrane, where it becomes plicated or thrown into folds around the margin of the crystalline lens. It is composed of a multitude of very small arterial and venous ramifications, connected by very fine areolar tissue, cells, lamellæ, and pigment granules. It is connected outwardly with the sclerotic by a thin areolar tissue interspersed with irregular shaped pigment cells, called the *arachnoidea oculi* or *lamina fusca*, and inwardly to the *membrana Jacobi retinæ*. The arteries come from the short ciliaries of the ophthalmic, piercing the sclerotic near the optic nerve, and are some twenty or thirty in number, which divide into branches parallel to the equator of the eye: they communicate and anastomose very freely, forming

a network on the concavity of the venous layer, constituting what is known as the *tunica Ruyschiana*. The veins, from their whirl-like arrangement, are called *vasa-vorticosa*, and converge to four nearly equidistant trunks, which empty into the ophthalmic vein, midway between the cornea and the optic nerve. The posterior ciliary veins pass out from the eye parallel to the entrance of the arteries. The pigment has been described above. The *annulus albidus*, or connection between the iris and choroid, is a flat, narrow band of a grayish substance, situated at the anterior end of the choroid, and serves to hold the retina and choroid around the vitreous body. According to Brücke it is formed of non-striated muscular fibres, converging from before backwards, and of circular fibres on a level with the union of the cornea to the sclerotic; the iris attaches itself to it by its greater circumference, a little behind the union of the cornea and sclerotic, upon a circular line which traces the separation between the anterior portions of the ciliary processes, and the internal face of the ciliary muscle or ligament: Graefe, of Berlin, has latterly discovered that some fibres bend forward to again cover the internal face of the ciliary ligament. Thus, whilst the areolar portions of the choroid appear to blend with the annulus albidus, its vascular portions, with large quantities of pigment, turn inwardly, posteriorly to the iris, anteriorly to the vitreous body, and as they approach the crystalline lens, are thrown into radiated folds called the ciliary processes, of which there are seventy in number, the whole of which is denominated the ciliary body, and is subdivided into a *pars plicata*, and a *pars non-plicata*.

The *dioptric apparatus*, or refractive media, consist of the cornea above described, the aqueous humor, the crystalline lens and capsule, and the vitreous body.

The aqueous humor is found in the anterior portion of the eye, immediately behind the membrane of Descemet, and anterior to the crystalline and folded ends of the ciliary processes: the iris divides it into two unequal compartments or chambers, viz: the anterior and posterior, which in the fœtus are completely unconnected by an occlusion of the pupil, by the *membrana pupillaris*. In extra fœtal life they are connected by means of the pupil; and, of the two chambers, the anterior is the larger. This fluid is composed of a small quantity of albumen, and of the various salts met with in the economy, particularly the chloride of sodium held in solution. It is secreted or formed from a membrane covering the posterior

wall of the iris and the anterior folds of the ciliary processes. The aqueous humor, when examined under the microscope, is found to contain only a few colorless cells; its form is somewhat of a meniscus, and measures at its greatest antero-posterior diameter about $\frac{1}{11}$ of an English inch. Its functions are those of refraction, which, in conjunction with the ellipsoidal cornea, the lens, and the vitreous body, serve to bring the light to a focus upon the retina.

The *crystalline lens* is a double convex or lenticular body, placed between the aqueous humor and the vitreous body, at the reunion of the anterior third, with the two posterior thirds of the ocular globe. Its diameter is nine millimetres ($\frac{7}{20}$ of an inch), and its thickness, corresponding to the axis of vision, is about half as much, five millimetres. The axis does not lie exactly in the centre of the eye, but slightly to the internal side, parallel with, or corresponding to the centre of the pupil and the axis of vision. The lens is more convex posteriorly than anteriorly; and its convexity is in an inverse ratio to the convexity of the cornea and the quantity of the aqueous humor. In density, degree of diaphanousness, color, and form, the crystalline lens presents marked changes in the different stages of life. Thus, in the fœtus it is reddish in color, not perfectly diaphanous, easily broken down, and is spherical, whereas in adult life it is perfectly transparent, the posterior surface becomes more convex, and the substance is firmer and colorless; and, in old age, it assumes a slightly yellowish or amber colored tint (sometimes so insensibly increased as to terminate in a loss of transparency or cataract); it becomes flattened, and gradually increases in specific gravity and firmness. By its external margin it is in immediate contact with a membranous sac, the *capsule*, the character of which is quite different on its anterior and posterior margins. The anterior border is free, whilst the posterior is lodged in a depression in the vitreous humor, and is much thinner than the anterior one; the whole sac is an amorphous, homogeneous transparent substance, brittle and breaking like glass, and carpeted on its inner layer by epithelial cells, with very fine granular spherical or oval nuclei. The tissue of the crystalline is composed of two sets of fibres, very regularly disposed above and by the side of each other, forming two distinct layers. The superficial ones are composed of nucleated fibres, forming a layer from $\frac{2}{10}$ to $\frac{4}{10}$ of a millimetre in thickness upon the surface, and are disposed parallel to each other of a size from $\frac{7}{1000}$ to $\frac{9}{1000}$ of a millimetre, flattened,

with clear edges, and finely granulous within the interior, with spherical or oval nuclei of $\frac{6}{1000}$ of a millimetre in diameter. The other fibres are called *dentelated*, and are firmer, narrower, smaller, paler, and more transparent than the former, and without any granulations in the interior, with notched borders, whence the name. The aggregate of the above described fibres form concentrated layers, easily separated when immersed in alcohol, and which are as a whole segmentated. The fibres pursue an antero-posterior direction; and it is remarkable that they do not converge to points on the anterior and posterior margins, but form radiating clefts like an orange. After death, when the capsule is punctured, there flows a peculiar liquor, which, according to the best authorities, is altogether a *post-mortem* production, and is known as the *liquor Morgagni.*

The canal of Petit is the name given to the space found between the ciliary and vitreous bodies, and which comprises the whole circumference of the lens; this canal does not in reality exist, but is made artificially, by the separation of the areolar tissue holding the parts together; this separation is made by the injection of air, which forms lead-like projections, united by bundles of tissue. Some authors suppose the canal of Petit to be a separation into two layers of the hyaloid, one going to the posterior border of the capsule of the lens, adhering to it and lining the *fossa hyaloidea*, and the other forming the ciliary zone, or *zonula* of *Zinn* (to be described), which is inserted into the circumference of the lens.

What is known as the *zonula* of *Zinn*, or ciliary zone, is the hyaloid membrane for the breadth of about $\frac{1}{5}$ of an inch, raised up into radiating folds, of a similar structure to the ciliary processes, into which it digitates and dovetails.

The vitreous body or humor lies in the middle and posterior parts of the eye, behind the crystalline lens, concentric with, parallel to, and within the retina. It is composed of a transparent semi-solid gelatinous substance, without either nerves or blood-vessels. It presents anteriorly a concavity, called the *fossa hyaloidea*, into which the larger or posterior segment of the lens is lodged; posteriorly it presents a convexity corresponding to the concavity of the retina. According to all anatomists, with the exception of some of the modern microscopical school, particularly M. Charles Robin, the vitreous humor is surrounded by a membrane of *enveloppe*, called the *hyaloid;* but, according to M. Robin, it is

surrounded posteriorly and laterally simply by the retina, and anteriorly by the posterior margin of the capsule of the lens, together with the ciliary processes in front.

But, according to others, the vitreous humor is contained in a segmentary membrane, which (according to Hannover) may be discovered "by a careful maceration in chromic acid, to consist of about one hundred and eighty delicate septa like the pulp of an orange," with the angles of the inclosed spaces in the direction of the axis of the eyeball, which do not meet, but leave a cylindrical portion for the passage of a branch of the *arteria centralis retinæ*, called the *arteria hyaloidea*, and the canal through which it passes is called the hyaloid canal of Cloquet. In the fœtus there is a vein corresponding to the artery, which conducts the blood from the posterior part of the capsule. Robin considers this canal to be *not* in existence, that there is no reflexion of the membrane, and that the artery having no investing membrane penetrates the substance proper. He also maintains that the vitreous humor is a special organic substance, entirely amorphous, not even fibroid; the fluid of which slowly drains away, when separated from the eye, leaving behind an amorphous and heterogeneous matter. Bowman has confirmed Hannover's experiments only in the fœtus. Kölliker thinks that it is an analogous condition to the embryonic areolar tissue, which after fœtal life completely disappears, and becomes a kind of more or less consistent mucus. The function of the vitreous body is the correction of prismatic refraction.

The visional or specially sensitive parts are the retina and the optic nerve.

The retina is the most internal of the tunics of the eye; it entirely embraces the vitreous body, and is situated between it and the choroid. Anteriorly it is limited by the *ora serrata retinæ*, where it is somewhat thickened, and appears to end in a defined margin. Robin, Bidder, and Valentin contend that it is continued over the inner surfaces of the ciliary processes, and connected to the hyaloid. Posteriorly it is connected with the *papilla conica* or *colliculus* of the optic nerve, which apparently it seems to constrict. Two lines exterior to the papilla, and in the centre of the visual axis, is found the *macula flava seu lutea centralis:* this, the yellow spot of Sœmmering (who first described it in 1791), is composed of a depression and a border. Sœmmering thought this colorless depression to be a canal, and hence named it *foramen retinæ centrales*, but wrongly, as

there exists only the above-mentioned depression: the border or ring alone is colored, and is called the *limbus luteus foraminis centralis*. Continuous with the limbus and extending towards the papilla, the retina is thrown into a fold, which is known as the *plica centralis retinæ*.

The retina, in the living subject, is normally transparent, but becomes opaque, of a grayish white color, upon decomposition, or subjection to alcohol or nitric acid. Formerly, the retina was supposed to consist of only three layers, viz: the *membrane of Jacob, the medullary, and the vascular layers*. The latest researches, however, indicate five different sorts of substances, arranged in successive strata.

I.	The layer of	columnar bodies	or	*stratum bacillorum.*
II.	" "	"	myelocytes	"	*stratum granulosum.*
III.	" "	"	corpuscles	"	*stratum gangliosum.*
IV.	" "	"	nerve-tubes	"	*stratum fibrillosum*
V.	" "	"	amorphous substance	or	*membrana limitans.*

The *stratum bacillorum* is formed of small cylindrical bodies, arranged side by side, and vertically to the retina; they consist of a peculiarly clear substance, from the $\frac{1}{100}$ to $\frac{6}{100}$ of a millimetre in thickness. Two kinds of bodies can readily be distinguished in this stratum: the cylinders or columns proper (*batonnet*, French, *stäbschen*, Germ.), which are transparent, flexible, and of a length varying from the $\frac{2}{100}$ to the $\frac{3}{100}$ of a millimetre; they are either *single or geminated* (twin-like), that is to say, curved in the manner of a horseshoe, with their free extremities on the same level; and *fusiform* (*cônes*, French, *zapfen*, Germ.), which are about the size and form of small cylindrical epithelial cells; they are slightly enlarged in the middle, finely granulous, and have delicate filamentous prolongations similar to the cylinder proper.

The layer of myelocytes, or *stratum granulosum*, is composed of numberless nucleated, small, and regular cells, which are scattered about in an amorphous substance, very much like the gray matter of the brain. This gray matter is most abundant in the anterior portion of the second layer, which is the thickest of the whole of the five strata.

The layer of corpuscles, or *stratum gangliosum*, is composed of ganglionic corpuscles, which send off filamentous prolongations, or cylinder axes, to the layer of myelocytes, and cylinders proper, to the continuation of some of the tubes of the optic nerve.

The layer of nerve-tubes, or *stratum fibrillosum*, is the spreading out of the optic nerve. The optic nerve at first sends out very delicate radiating fibrillæ, interlacing with various plexuses, with elongated meshes, which continually diverge, and the spaces between them constantly undergo an increase. With regard to the termination of this stratum, anatomists disagree. Valentin says that they end in loops upon the anterior margin of the retina. Hannover contends that they end by free extremities. Robin, who seems to have investigated this matter more thoroughly than any one else, says that they do not reach the anterior margin or fringed border, but terminate upon the whole surface of the retina, most probably in the ganglionic corpuscles. Some of them go directly to the yellow spot of Sœmmering, and terminate at its periphery, where they surround it, forming two bundles or two quite large rolls, and which, in all probability, form the *plica* or folds there visible. The depression in the yellow spot is owing to the absence of this layer: all of the other strata being there found. This layer is composed altogether of gray matter, and, what was latterly demonstrated by Todd and Bowman, was long ago suspected: viz., that none of the white substance of Schwann enters into the composition of the retina.

Fifthly, there is found in the retina an amorphous substance, known as the *membrana limitans*, which is parallel and anterior to the *stratum fibrillosum*, and passes in front of the ciliary processes to the capsule of the crystalline lens, where it terminates in a circle. This is the only layer of the retina which is vascular, the central artery and vein ramifying throughout its extent. According to H. Müller, various fibres are detached from this membrane (fibres of Müller), to pass through the thickness of the other layers into the cylinders proper of the *stratum bacillorum*.

The *optic*, or second cranial nerve, is one of special sense, and is entirely distributed to the eye. It springs from the superficial layer of the optic tract, which arises from the *thalamus opticus*, *corpora quadrigemina*, and *corpora geniculata*. Leaving the under part of the thalamus, it makes a sudden bend forwards, and strikes obliquely across the inferior surface of the cerebral peduncle, assuming a flat ribbon-like appearance. Before reaching the *sella turcica*, it assumes a more rounded form, where it decussates with its fellow, forming the *chiasma* or commissure, previously, however, having received an accession of fibres from the *lamina cinerea*, and having

an adherence to the *tuber cinereum.* "The fibres of origin of the optic tract from the thalamus are derived partly from the superficial stratum, and partly from the interior of that body. According to Foville, this tract is also connected with the *tænia semi-circularis*, and with the termination of the *gyrus fornicatus;* and he states, further, that where the optic tract turns round the back of the thalamus and the cerebral peduncle, it receives other delicate fibres, which descend from the gray of those parts." (Mayo, *Outlines of Anatomy*, p. 514.) The nerve, after leaving the commissure, passes through the *foramen opticum* of the sphenoid bone, being previously invested with a sheath from the *dura mater*, and passes, surrounded by the recti muscles, to, and then through the sclerotic and choroid tunics at the back of the eyeball.

The nerve is composed of fasciculi of microscopical primitive fibrils, inclosed in a neurilemma, the whole being again incased in a larger neurilemma. As the nerve penetrates the sclerotic, the neurilemata of the fibres cease; hence the apparent constriction of the nerve at that place. About four lines from the sclerotic, the nerve is penetrated by a canal which transmits to and fro, the central artery and vein of the retina.

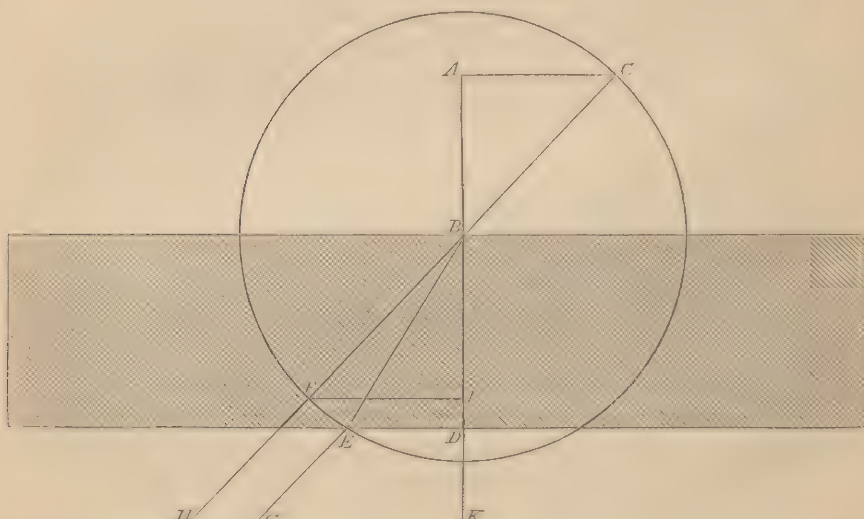
With regard to the circulation of the eye, as well as its development, it would be foreign to our present purpose, and also would extend this essay to a most formidable length, were we to enter into it in a manner worthy of its importance; hence we must leave it untouched. We have thus sketched, almost superficially, the anatomy of the eye. Why we have so done, is readily apparent; and its bearing upon the physiology of vision is at once comprehended.

According to the proposed plan, the physiology of vision will now be sketched.

Vision is a function of relative life, of which the eye is the apparatus, through which we perceive one of the qualities of physical bodies, denominated luminous. The perception of these luminous bodies is subject to the above mentioned laws of optics. Of these laws we propose to enter upon the demonstration of but one, viz: that of refraction. The facts that opaque bodies reflect light, and transparent bodies transmit it, are such as need no demonstration, and they are but secondary to our object; but, a ray of light entering in an oblique manner, from one medium to another, the direction is changed, or rather the ray is bent either to or from the perpendicular, which phenomenon constitutes refraction.

Thus, if a ray passes from *A* perpendicularly to the surface of the piece of glass at *B*, it will pass to *K* in the right line *A B I D K*. But if the same ray be directed to the surface *B* obliquely, as from *C*, instead of passing through in a direction *C B F H*, it will be refracted to *E*, in a direction approaching the perpendicular *A K*. The ray of incidence is *C G*, and the angle *C B A*, made with the perpendicular *A K*, is denominated the angle of incidence. The refracted ray is *B E*, and the angle *E B D* is the angle of refraction. The ray from *C* to *B*, and refracted to *E*, is as much bent from the line of the refracted ray *B E*, as it was from the line *C B F H*. Hence,

Fig. 1.



it follows that a ray passing through a transparent medium having two surfaces on parallel planes, is refracted from its original course, and in passing out is bent parallel to the original line. Now, if a circle be described about a centre *B*, with any radius as *B E*, the arc *D F* measures the angle of incidence *D B F*, and the arc *D E*, that of the angle of refraction *D B E*. A line *F I*, brought from the point *F*, perpendicular to *A B I D K* is the sine of the angle of incidence, and the line *D E* is the sine of the angle of refraction *E B D*. Hence, it follows that the sine of the angle of incidence has the same ratio to the sine of the angle of refraction, it matters not in what degree of obliquity the incident ray *C B* is thrown upon the transparent medium. Dr. Arnot draws, after en-

tering very minutely into the details of a very long mathematical calculation, the following conclusions from the above theorem. "If any ray of incidence passes from air obliquely into water, the sine of incidence is to that of refraction as 4 to 3; if it passes from air into glass, the proportion is as 2 to 3; and if from air into diamond it is as 5 to 2."

Having thus premised the phenomenon of refraction, its application to the study of vision is readily appreciated. The cognizance by the retina of an object, is the combined result of the impinging of rays of light upon the retina, and a sensation communicated to the brain by means of the optic nerve. These sensations are produced by colors and their refraction and reflection, all of which are subject to the laws of light: they cause us besides to perceive certain characteristics in a mathematical order, such as situation, form, and size, subject to judgment and comparison, which apply the phenomena of reflection and refraction produced by these bodies. Hence it is, that errors of judgment produce deceitful appearances, which errors are induced by, either the manner in which the light is reflected, or according to its intensity, or whether it strikes one or both eyes, or according to the conditions of the refractive media, their curvature, etc. etc. Were we dependent entirely upon judgment for the perception of bodies, we would frequently be deceived, but the sense of touch causes us specially to recognize the peculiarities to which vision is subjected.

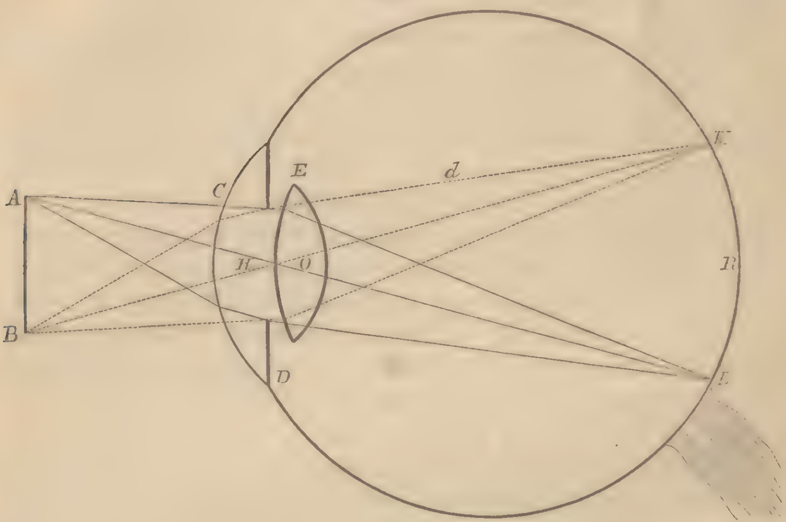
The phenomena of vision are, A, purely *physical*, beginning at the cornea and ceasing at the retina; and B, *organic* or specially sensitive, depending upon the properties of the nerve, which begin where the physical ones cease, and cease themselves in that portion of the brain which *perceives.*

Every object sends off a cone of luminous rays, which so long as they pass through a medium of the same density, proceed in straight lines; but when they enter a denser medium undergo the refraction above demonstrated. Whether, as Newton and Descartes maintained, light be a material substance emitted from luminous bodies, thence conveyed to the eye, thereby rendering them visible, or as Dr. Young considered it, to be undulations propagated through a fluid (the doctrine at present generally admitted), it matters not for our present purpose: its discussion rather belongs to the Secondary Mechanical Sciences, than to a brief essay upon vision. Whatever be the adopted theory, this light, before producing the desired effect, undergoes four successive refractions:—

I. From the air or object A B to the cornea, which refracts it in consequence of its density and convexity.

II. From the cornea C, to the aqueous humor H, which causes it to be bent slightly to the perpendicular.

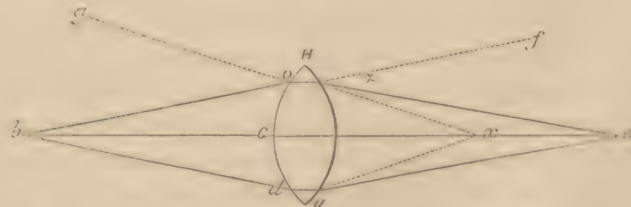
Fig. 2.



III. From the aqueous humor H to the denser and more convex crystalline lens O, where it undergoes a new refraction, following the general law.

IV. The last and chief refraction is from the denser medium the lens, to the rarer one the vitreous body. Thus, in the crystalline

Fig. 3.



lens, the ray b o is bent to the perpendicular o g prolonged, and passing through follows the direction o z, and in passing out approaches the line b a; but it passes to the rarer medium, the vitreous body (Fig. 2, d), by which it is again bent from the perpendicular.

Thus (Fig. 2), if from the assumed points A B, light be emitted, the image will be formed upon the retina, R, upon the points K L; the image thus produced is inverted, constituting one of the *paradoxes* of vision, of which hereafter. There are two circumstances which will prevent the perfection of the above mentioned image, were not the eye so perfectly adapted to its ends. Thus *Spherical Aberration* is corrected by the combination of the aqueous humor and the iris; the former from its refrangibility, the latter acting as a stop or diaphragm, in such a manner that only the central portion of the crystalline is used. *Chromatic Aberration* is corrected or remedied by the conjoint action of the crystalline and the vitreous body, the latter exercising the greater dispersive power, and also from its offering a concavity to the convexity of the lens. All of the refractive media conjoin to produce the image upon the retina, which is clear and precise if these media be correctly adapted, and if they be incorrectly placed, the image is indistinct and confused. The *adaptiveness* of the eye to distance, is one of the prerogatives of sight, and, as such, its mechanism is truly wonderful. The power by which it adapts itself to variations of distance, whether it be the small distance between the eye of the engraver and the steel, or the vast expanse of old ocean's mightiness, has as yet been unexplained, at least in a satisfactory manner. Whatever be the distance of an object from us, it is a matter of no immediate perception, but is a judgment and inference drawn from our sensations. The elements upon which our judgment is based, are, the effort by which the two eyes are fixed upon the same object, and that by which one or the other eye is adjusted to distinct vision; and, the colors, forms, and volume of objects, as compared with each other's appearance. The correct interpretation of the whole is gradually learnt by experience, the rapidity and unconsciousness of which process are not more remarkable than the acquirement of speech and the capability of reading. Having acquired the conception of the relation of position, or in other words, the ratiocinative faculty of vision, by what faculty then is this accomplished? Brown[1] denies *touch*, but *advocates muscular sense*, which is but another name, and is but the consciousness of an exertion of the various muscles by which we move our limbs; for our knowledge of the forms of bodies is acquired by the perception of the course of the fingers, following

[1] Brown, Lectures of the Philosophy of the Human Mind.

their surfaces. Sir Charles Bell[1] calls this *consciousness* of muscular action a "sixth sense," which Marshall Hall more fully developed in his various writings upon the reflex-motor actions of the nervous system. The conclusion at last, is, that by the modifications of touch, or by touch itself, the relation of position is readily comprehended, and that it is fundamentally and inseparably connected with our own actions in space. A doubt seems to have arisen as to the fact whether a person born blind, who previously by *touch* could distinguish mathematical figures, a cube and a sphere for instance, on suddenly obtaining vision, would be able by this sense to recognize them. Locke[2] denied the possibility of so doing, and with justice: he arrived at this conclusive point by reasoning, which has subsequently been proven by facts. Cheselden relates the case of a lad born blind, who at the age of twelve years, was, by an operation for artificial pupil, restored to sight. This boy saw everything flat as in a picture, simply receiving the impression upon the retina, without being able to refer it, and it was for a long time before he had the power of judging, by vision, of the real distances and forms of objects around him. He was incapable of distinguishing a dog from a cat, until he touched them. Carpenter[3] relates a similar instance, of a boy who preferred to find his way (after being restored to sight), through his father's house by *touch*, rather than by sight alone.

Among the new-born of the lower animals, the capacity for estimating distance results from some immediate power, and they manifest, at an early moment, that which takes man a long time to acquire. They perform automatically or instinctively, these actions in obedience to internal impulses, without even the perception of their adaptiveness on the part of the being who is their agent. All of these impressions are called into play, by the action of external objects, or by changes in the individual organism. Now, whatever be the refraction undergone by the rays emanating from a luminous body, the spot where the image is pictured upon the retina, is determined by the prolongation of a ray which represents the centre of a cone, whence an inverted image is the result, *vide* Fig. 2, the point B is represented upon the retina at K, and the point A, at L. The angle formed by two central rays, C and D,

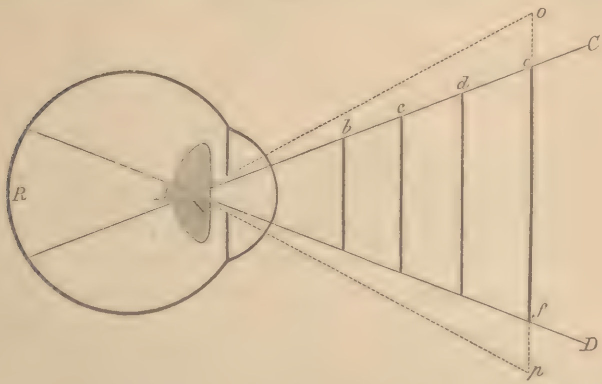
[1] Bridgewater Treatise, p. 195. Phil. Transactions, 1826. Pl. II. p. 167.

[2] Locke, On the Human Understanding.

[3] Carpenter, Principles of Human Physiology, p. 676, Am. ed. edited by F. G. Smith, M. D., Philada.

Fig. 4, is known as the visual angle, and it follows as a consequence that objects situated at various distances from the eye, project images of equal size, provided they subtend the same angle. Hence the estimate of the *size* of an object is partly dependent upon the

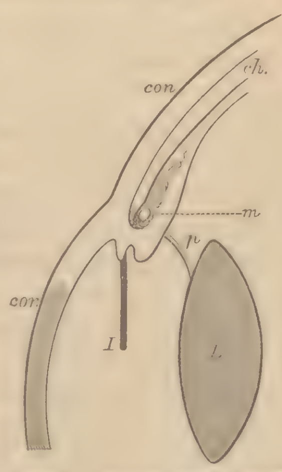
Fig. 4.



visual angle, and partly upon its distance, and the condition of the atmosphere. Thus if two objects, *o p*, *e f* (Fig. 4), the former twice the length of the latter, are placed at the same distance from the (*R*) retina, it is obvious that the angle *O X P* is twice the size of the angle *e x f*.

The faculty of the eye to accommodate itself to distances is physically owing to the displacement of the crystalline lens, through the action of the ciliary muscle (*tensor ciliaris*), and the erectile tissue of the ciliary processes. Although comparative anatomy would tend to prove this statement, yet in the human subject it has never been demonstrated by observation. Among the predaceous birds (the strix bubo (common owl) above mentioned), distinguished for great range of vision, there is a very firm attachment for the tensor ciliaris, in the osseous plates of the sclerotic. Another fact to go to prove this statement, is that

Fig. 5.

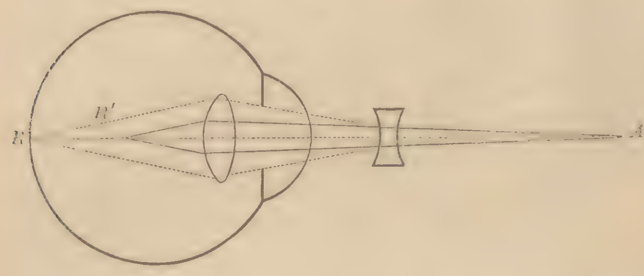


L, lens; *P*, junction with the assumed canal of Petit; *I*, iris; *cor*, cornea; *con*, conjunctiva; *ch*, choroid; *m*, the tensor ciliaris, showing a projection of the muscle and its connection with the lens.

with persons operated upon for cataract, there is an entire absence of the power of adapting the eye to distance.

Hence, this adaptiveness in the curvature of the refractive media, such as the cornea, aqueous humor, lens, and vitreous body. The most frequent conditions of abnormal vision are short-sightedness, *myopia*, and long-sightedness, *presbyopia*. Myopia is dependent

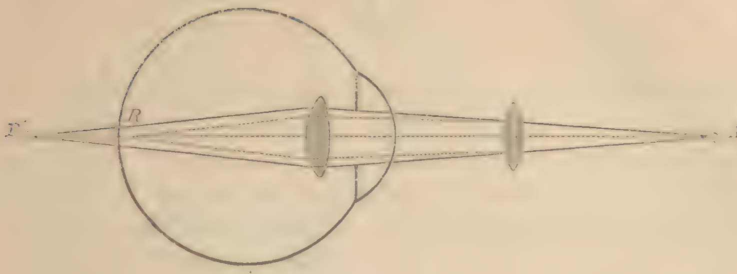
Fig. 6.



upon a condition of the refractive media, whereby the rays of light are so influenced that they converge so much as to unite before reaching the retina. The diagram illustrates this condition as well as its remedy by a concave glass, shown by the dotted lines reaching the retina. The physical causes which produce this condition of vision, are either an excess of density and a too great prominence of the cornea, or a superabundance of the humors of the eye, or a too great density or convexity of the crystalline, or an enlargement or dulness of the pupil, or a preternatural density of the vitreous body, or an over-activity of the power inherent in the eye, of adapting itself to the seeing of near objects, etc. etc. Were we to enter into the discussion of any of the above conditions necessary to the production of myopia, it would cause this essay to be of a too great length; hence, we must unwillingly pass over them, regretting our inability, at present, to inquire into this most interesting branch of optics.

Presbyopia is just the reverse of myopia, and is a confusion of vision, when near objects are looked at, while distant objects are distinctly seen. It is dependent upon a condition of the refractive media whereby the rays of light do not converge sufficiently soon, and hence do not reach the retina before coming to a focus. It is remedied (*vide* Fig. 7, dotted lines) by a convex lens, which produces the convergence necessary to throw the image upon the retina, by bringing the rays into a focus at that point.

Fig. 7.



The concomitant causes of this affection are generally, flatness of the cornea, shortening of the axis of the anterior chamber, diminution in the size of the pupil, and an apparent sinking of the globe within the eye. The same remarks made concerning the discussion of the causes of myopia, are equally applicable to those of presbyopia. . . . .

There are many other abnormities of vision, resulting from defective refractive media, which for a want of space cannot be described. Among them, however, there are two which we deem proper to notice, viz., astigmatism, and dyschromatopsia. Astigmatism (α privitive, and στιγμα, point) is a result of defective refraction in such a manner that the cornea and lens are so arranged, as to prevent the production of a focus, when the rays of light are presented in a vertical direction; and, when presented in a horizontal direction, a focus is produced. Thus, if a straight black line be drawn upon a piece of white paper, and viewed horizontally, nothing abnormal appears; but if presented vertically, it seems to be double. In the *Philosophical Transactions* for 1801, Dr. Young, in his article on the *Mechanism of the Eye*, mentions that his own eye, "in a state of relaxation, collects, to a focus on the retina, those rays which diverge vertically from an object at the distance of ten inches from the cornea, and the rays which diverge horizontally from an object at seven inches distance." What, then, is the explanation of the above phenomenon? It appears to us to have been caused by the light falling upon the whole surface of the pupil, and not brought to one corresponding point, or focal spot within the eye, thereby producing two linear images at right angles to each other. And it is probable that in all *astigmatics*, the cornea is without the "surface of revolution," and that its curvature is less in the horizontal than in the vertical plane; that the lens has one or both surfaces cylindrical, and varies in symmetry

and density. In the case of Dr. Young, he considered himself to be affected with an "obliquity of the cornea and crystalline lens, with respect to the visual axis."

Gerson[1] relates the case of Prof. Fischer, of Berlin, who observed that, if a number of parallel lines were placed before him in a horizontal direction, he could distinctly count them at the distance of from fifteen to twenty inches, and when changed to a vertical position, they presented a confused appearance, until brought within five or six inches of the eye. Also, when Prof. F. looked at the bars of a window, in an upright position, the cross bars appeared longer than normally, and when he hung his head upon his shoulder, the upright bar assumed an elongated appearance.

The most remarkable instance of the defect occurred in the no less celebrated personage than the distinguished Mr. Airy,[2] the Astronomer Royal of Great Britain. The publication of this case led to the investigation of the subject, and the defect has been found not to be so uncommon as previously supposed. Dr. Hays,[3] of Philadelphia, details an account of a clergyman of that city, astigmatic in both eyes. Dr. Goode[4] relates his own case. Dr. Hamilton[5] describes a case of double astigmatism. The writer of this paper was consulted by a negro for what he himself denominated "upside-down sight," which, after a tedious and patient investigation, proved to be astigmatism. This patient was unable to distinguish or reckon time by the hands of a clock, whenever it was at a full hour, and from that peculiarity he knew it was the full hour; the quarters, halves, and fractional halves, were very distinctly told. Up to his death, he suffered from the defect, being unable to procure a lens, which was concavo-cylindrical on one side, and plane upon the other. The action of such a lens is owing to the cylindrical shape, "producing no convergency or divergency in parallel rays, incidental to the plane of the axis, whilst it converges or diverges rays in a plane at right angles to the axis, as a spherical surface of equal curvature would do." As we cannot, or at least do not, feel disposed to enter into the rationale of astigma-

[1] Gerson, De Formâ Corneæ, p. 17. Göttingen, 1810.

[2] Transactions of the Cambridge Philosophical Society, vol. ii. p. 267, *et seq.* Cambridge, 1827.

[3] Lawrence, Diseases of the Eye, p. 669, edited by Isaac Hays, M. D. Philadelphia, 1854.

[4] Cambridge Transactions, *loc. cit.*

[5] Monthly Journal of Medical Sciences, p. 711, April, 1848.

tism, we would omit anything more on the subject, as it can be found minutely detailed by Mr. Airy, in the *Cambridge Philosophical Transactions*, vol. ii. 1827, and in Mackenzie's work on the Eye.

The second abnormal phenomenon is known as *Dyschromatopsia* (from δυς, difficult, χρῶμα, color, ὦψις, sight), or insensibility to certain colors, the color-blindness of Sir David Brewster. Of late years, this affection has been very much investigated, and the propriety of such is readily appreciated, when we know that human life is at stake, and that many sad accidents have taken place on account of mistakes as to the color of railway and marine signals. Many instances are on record of individuals who were totally incapable of appreciating various colors, and of mistaking one color for another, such as orange for green, or *vice versa*.

Dr. Darwin, the poet and botanist, could distinguish a cherry from the leaves only by its shape. There is another case of a family in York, England, who were similarly affected with regard to full reds and full greens. Dr. Dalton, the discoverer of the Atomic Theory, and distinguished chemist, was likewise similarly affected. This defect was not known to him until, one day, discussing with a friend concerning the nomenclature of the colors of the solar spectrum, Dalton was unable to distinguish red, and all of the others consisted simply of yellow and blue. When made aware of his defect, it is said that he consigned to the flames a large manuscript, the contents of which were unknown. Dalton knew of twenty persons similarly affected as he was. Twice, with different classes of twenty-five pupils, he explained the defect, and detected the same misfortune in two of them. Prévost declared that five per cent. of the human race were color-blind.

Dr. Wilson seems to doubt Prévost's numbers, if applied to such cases as Dalton's, but admitted them with regard to blue and green; for out of 1154 persons examined in the city of Edinburgh alone:—

1 in 55 confounded red with green.
1 " 60 " brown "
1 " 46 " blue "

The proportion with respect to blue and green was accidentally discovered, as it was unsought for. With regard to red and green, and brown and green, they are, according to Dr. Wilson, but "degrees of the same affection; all in the first category, red with green, must be added to those in the second, brown with green; and many of those in the second might appear in the first; but no

one was counted more than once." Many cases have been related and detailed in various journals, books, and monographs, which were spurious, being diseases of the retina, and readily recognized by the ophthalmoscope; one such will hereafter be described.

There are two great classes of the color-blind, which differ in degree and character. Mr. Seebeck has given the best classification, and as such we will quote it. Seebeck's first class consists of those who differ considerably in the degree of their vision, yet agree very nearly in the confounding of the following colors.

"1. Sky-blue, gray-blue, and gray-lilac.
2. Lilac and bluish-gray.
3. Bluish-green and imperfect violet.
4. Crimson, dark green, and hair brown.
5. Rose-red, green (rather blue than yellow) and gray.
6. Pure light green, gray-brown, and flesh color.
7. Intense orange, light yellowish-green, or brownish-green, and yellow-brown.
8. Light orange and pure yellow."

Persons who come under this class, have generally a very imperfect idea of all colors, but particularly confound red with green, which appears to be of a dull gray; they also give the latter appearance to blue. Yellow they distinguish the most perfectly, but still lack the acuteness of perception of the normal eye.

Individuals of the second class have only an imperfect perception of the least refrangible rays, which is not the case with those of the previous class. These persons also recognize yellow the best, distinguish red better, and blue not so well as those of the other class. They more particularly confound:—

"1. Dark violet and dark blue.
2. Crimson and violet.
3. Rose-red, lilac, sky-blue, and gray (including lilac).
4. Brick-red, rust-brown, and dark olive-green.
5. Cinnabar-red and dark brown.
6. Imperfect (somewhat yellowish) rose-red and pure gray.
7. Flesh-red, gray-brown, and bluish-green.
8. Dark carmine and blackish blue-green.
9. Light orange, greenish-yellow, brownish-yellow, and pure yellow.
10. Bright orange, yellow-brown, and grass-green."

In speaking of the vitreous body, we mentioned Hannover's discovery of the segmentary disposition of that body, as revealed after a maceration in chromic acid. This discovery seems to have been totally neglected by all writers upon the subject of color-blindness, which, if properly reviewed, would explain the phenomenon, and suggest a remedy. The writer believes an explanation of the defect

of color-blindness can be made by the above mentioned segmentary arrangement of the vitreous body. Thus, we know the laws of the refraction of light, and the peculiar property which a triangular prism of glass possesses of refracting light, and of decomposing it into seven primary colors. For the knowledge of this fact, we are indebted to Sir Isaac Newton. He placed a prism opposite an orifice in a window-shutter, admitting a ray of light in a darkened room, and, as the result, the pure white light was found to be composed of seven brilliant colors, viz: violet, indigo, blue, green, yellow, orange, and red.

The solar spectrum with regard to each particular color is vivid only at particular parts, as they blend and mingle with each other in such a manner that it is difficult to say where each begins or ends. The violet rays bend most from their course, whereas the red ones are the least turned out; the other colors possess this property in the proportion as they are mentioned in the list. These seven colors were named primary, and considered as simple or homogeneous, particularly as they preserved their individuality when passed through another prism. Notwithstanding our incapability of analyzing these rays, they can synthetically, some of them at least, be shown to be compound. For artists have demonstrated that red, blue, and yellow would form all of the tints of the prismatic spectrum, and as no mixture would produce these colors, they were necessarily simple or homogeneous; and the others, viz: violet, indigo, green, and orange, as a natural consequence, were compound or heterogeneous. Every one is familiar with the experiment of Buffon, who showed that by steadfastly looking at a red, yellow, or blue spot, upon a black or white ground, a fringed border is recognized around each one of them, the tints of which are composed of three colors: thus, a green border is seen around the red spot, and green is composed of yellow and blue; a violet border is observed around the yellow spot, and violet is made up of blue and red; an orange border is perceived around the blue spot, and orange is a mixture of red and yellow. The experiments induced to explain the phenomena revealed by Buffon's experiments remained unsatisfactory, until Mr. Hay, of Edinburgh, scientifically demonstrated them in his work on the *Laws of Harmonious Coloring*. Sir David Brewster, Dr. Neil Arnot, F. R. S., Professor Holmes, and many other scientific persons have concurred with the opinions advanced by Mr. Hay. The writer of this essay has frequently verified them: his procedure and results are the following,

corresponding almost in every particular with those of the learned gentleman of Edinburgh. A prism was fixed in a hole in a shutter admitting a ray of light in a darkened room, and the decomposed light thrown upon a screen. Each color was successively put to the test, and was found incapable of being divided into two. A hole then was made in the screen, corresponding to the centre of the red of the spectrum, and another in that of the blue, and these colors were allowed to fall on a second screen. By means of a second prism the red ray was directed to the spot where also the blue appeared, in which spot they combined to produce as pure and intense a violet as was seen upon the first screen. Red and yellow were subjected to the same experiments, and a beautiful orange sprang forth; yellow and blue thus treated produced the prismatic green. After the above experiments were performed, a simple ray was thrown upon a compound color, and did not unite, for, as soon as red was thrown upon green, it vanished and black resulted; thus it was with the whole series. In another course of experiments two spectra were used, the one behind and of course a little above the other, and the same results were adduced. Thus, by synthesis, it was clearly demonstrated that the three homogeneous colors, yellow, red, and blue, had an affinity for one another, which was wanting in violet, indigo, green, and orange; and, as a consequence, they could not be the same in every respect, save color and refrangibility. The three homogeneous colors, yellow, red, and blue, are in a numerical ratio as follows: yellow 3, red 5, and blue 8; and when any opaque body reflects these colors in such proportions, white is the result. In this condition they are in the active state, and each is neutralized by the relative effect of the others. These rays when in the *passive state* are absorbed, and black is the result. The effect is the same when transmitted through a transparent substance, but are *material or inherent* in the first case, and *impalpable or transient* in the second. Hence, color solely depends upon the refractive or reflective power of bodies. The opinion at present most generally received is, that according to the disposition of the minute particles of various bodies, so is their power of reflecting and absorbing rays; and as is the reflection and the absorption so is the color, which is not of itself an inherent part of a body. Color, when produced by artificial light, such as by oil, candles, or gaslight, the rays of which are not so pure as those of the sun, is very apt to be deceptive, so much so that every one will mistake pale blue for green, or *vice versa*.

What, then, is color? Color is the reflection of the rays which the object does not absorb! A white color is the reflection of all the rays, a black their absorption. A poppy is red because it absorbs all the other rays of the prism and reflects red; but, if it be seen through the medium of a compound color, a green glass for instance, there is an interference of rays, and the brilliant poppy appears to be black. Numerous instances of these apparent paradoxes might be enumerated; but these, as well as the discussion of the heat and actinic rays of the prism, are necessarily crowded out for the want of space.

Sir Isaac Newton discovered that different rays require different distances to bring them to a focus, or, in other words, that the momentum of each ray is different. The red is the soonest brought to a focus, and has the greatest momentum. It is on this account that in a fog the sun appears red, from the rays of this color possessing the force or momentum to penetrate the dense atmosphere.

White light has the regular recurrence of periodical movements at equal intervals (500,000,000,000,000) five hundred millions of millions in one second. Red to produce its effect undergoes (482,000,000,000,000) four hundred and eighty-two millions of millions in $\frac{1}{60}$ part of a minute! Yellow, to produce its sensation, affects the eye in one second (542,000,000,000,000) five hundred and forty-two millions of millions of times. Violet, to do likewise, must vibrate in one second's time (707,000,000,000,000) seven hundred and seven millions of millions of times.

Of all modern investigators, Sir John Herschel seems to have arrived at the most correct data with regard to the length and rapidity of the various rays of the solar spectrum; he gives them as follows:—

Colored rays.	Length of luminous rays in parts of an inch.	Number of undulations in an inch.	Number of undulations in a second.
Red	.0000256	39180	477 billions.
Orange	.0000240	41610	506 "
Yellow	.0000227	44000	535 "
Green	.0000211	47460	577 "
Blue	.0000196	51110	622 "
Indigo	.0000185	54070	658 "
Violet	.0000174	57490	699 "

The relative intensity of the light of the various portions of the solar spectrum, according to the calculations of Frauenhofer, are numerically expressed as follows:—

Violet	from 5 to 6
Blue, dark (indigo)	31
Blue of solar spectrum	170
Green	480
Between orange and yellow	1000
Orange	640
Red, middle ray	94
Red, extreme ray	22

Having cursorily glanced at the theory, and the facts of color, we are prepared to enter into an explanation of the phenomenon of color-blindness. Rejecting all opinions heretofore maintained, not as worthless, for many of them merit the most distinguished consideration, but as certainly not giving a very correct idea, the writer presumes the following:—

A. That light is transmitted by undulations.

B. That the different colored rays of the solar spectrum may be accounted for, by a difference in the frequency of recurrence in the vibrations.

That light is transmitted by undulations, no one doubts, and its discussion here would be *mal-apropos.* With regard to proposition B, the simple facts will be stated, not discussed. The diffraction and interference of light present phenomena which go to prove it; such as Newton's luminous rings, Grimaldi's *interior* and *exterior* fringes, and the estimates above mentioned.

Remembering Hannover's discovery that the vitreous body is composed of a series of segments, the writer believes *color blindness to be the result of an irregular prismatic refraction of light as it passes through that dioptric medium.* What conditions combine to produce such an effect, physical research has as yet been unable to demonstrate, but *a priori* reasoning by exclusion tends to that effect. For there are bodies which will transmit one kind of color and reflect another, leaf gold for instance, which transmits yellow, but reflects green. Again, some substances only reflect the various rays, thereby producing color, when they are of a certain thickness, beyond which they appear black. Most of the color-blind, and particularly in such as Dr. Darwin, the segmentary arrangement of the vitreous body is such as to induce a decomposition of light, and to bring the focus of two colors, a simple red and compound green, upon the same spot of the retina, and as a consequence their mutual disappearance, as proven by the experiments above quoted by the writer upon harmonious coloring. Now, if all phenomena ex-

hibited with regard to that abnormal process of vision (or color-blindness), can be produced physically by a series of prisms, does it not follow (as no other series of lenses can bring about the same effects) that it is reasonable to suppose the impressions conveyed to the brain by means of such images upon the retina, are similarly produced by a similar series in the vitreous body? We emphatically answer in the affirmative!

When we gaze upon the faultless beauty of the humble violet, the brilliant jonquil and the modest lily, we little suppose that billions of vibrations must take place before the proper image is formed upon the retina, and the sensation conveyed to the sensorium! What innumerable vibrations take place, when we look around and behold the various hues of all that exists in nature from the humblest pebble to the sublime snow-capped mountain! Yet, of all the millions of millions of vibrations, if *one only* should be lost, the color would be imperfect!

It thus seems, without reapplying the laws of coloring in detail, that color-blindness is a purely physical result of a disarrangement of the vitreous body, and that its remedy is the application of such substances, the wearing of various glasses for instance, such as light or deep orange, rose tinted, etc., with a certain amount of convexity or concavity, as the case might warrant, thereby preventing an interference of rays. We sincerely hope to see color-blindness as easily remedied, as either presbyopia or myopia.

Besides the above mentioned phenomena of vision, there are others which are entirely *subjective*, that is, such as afford evidence of the action of the retina, and which are not dependent upon the influence of the external agency of light. The most remarkable of these subjective phenomena, are what are denominated by M. Serre (d'Uzes) *Phosphènes* (Φῶς, *light*, and Φαίνειν, *to cause to shine*), and *Druckfiguren* by Purkinje. These are luminous images which are produced by pressure upon the ocular globe, whence a mechanical action upon the retina. The procedure of M. Serre consists in suddenly and gently tapping either with the extremity of the finger or the head of a pencil (over the closed lids) the globe of the eye, which produces the luminous rings in question.

The partial or entire absence of these rings, their indistinctness, or their segmentary appearance, is a precious source of diagnosis which permits us to recognize any threatening or actual lesion of the function of vision. The method of the writer to obtain the development of these phenomena, is to place the patient in a dark

room, and then proceed as M. Serre in the manner above described. The beneficial advantage which these *phosphènes* offer to the surgeon, is to enlighten him upon the state of the retina as regards the feasibility of an operation for artificial pupil, when adhesions or cataract totally obstruct the passage of any rays of light. M. Serre mentions four particular *phosphènes*, viz: *jugal*, *frontal*, *temporal*, and *nasal*. To produce either of which the eye must be compressed upon the opposite side; thus, to produce the *nasal*, the temporal margin of the globe is pressed upon or tapped, and so on with the others. In the first degree of *anæsthesia retinæ*, the *jugal* disappears; in the second, the *frontal;* in the third, the *temporal;* in the fourth, the *nasal*. When the latter is wanting, the others cannot be developed; but, in an inverse order, when the *jugal* is absent, the others remain; when the *frontal* is also absent, there still remain the other two; and when the *temporal* is also absent, the *nasal* remains, the obliteration of which indicates a complete *anæsthesia* or loss of sensibility in the retina. When, after an active or other treatment, the *phosphènes* begin to reappear, they do so in an inverse order to their disappearance; thus, the *nasal* being the last to disappear, is the first to reappear; then the *temporal*, *frontal*, and *jugal*. When the *jugal* phosphenic light is wanting, its absence indicates that the terminal portion of the retina alone is anæsthetic; the non-appearance of the *frontal* implies that a more distant portion is implicated; and the absence of the *temporal* and *nasal* ones, point out that a loss of sensibility has reached still more distant portions. The other subjective phenomena are of such physiological importance that space will not permit of their discussion; a mere mention will have to suffice.

A. Luminous appearances produced by the pulsations of the *arteria centralis retinæ*.

B. Phosphenic circles made apparent by a sudden lateral motion of the eyes.

C. Vascular figure, and visible movement of the blood, presenting a luminous appearance in the field of vision.

D. Electrical and galvanic productions of phosphenic circles.

E. Spontaneous phosphenes.

F. Narcotic and rotatory phosphenes.

We now propose to entertain, in as concise a manner as possible, some few of the peculiarities of healthy vision.

Vision is subject to two paradoxes; the first of which, *upright* or *erect vision*, or the seeing of objects upright by inverted images upon the retina. The second is the faculty of *seeing single with two such images.*

With regard to the solution of the cause of erect vision many theories have been advanced, which are as yet unsatisfactory. Kepler presumed that objects appeared erect, on account of the mind's perception of the impulse of a ray on the lower part of the retina; and he thought this ray to be directed from a higher part of the object, and *vice versâ*. The opinion most in vogue is that of Porterfield, sanctioned by Sir David Brewster and Mr. Reid, viz: that the mind never sees the picture painted upon the retina, and consequently never judges of the object. According to this law, all objects are seen in the direction of the perpendicular to a point of the retina, upon which any impression is made; hence, in seeing any object, in consequence of an immutable and known law, *the sensation is traced by the mind back from the sensorium to the retina*, and thence referred in consequence of the perpendicular lines to its proper place without the eye: or in the words of Carpenter, "as all the perpendiculars to the several points of the inner surface of a sphere meet in the centre, the line of direction of any object is identical with the prolonged radius of the sphere, drawn from the point at which its image is made upon the retina." Volkman,[1] upon a close examination, found this law to be optically incorrect, since the lines of direction cross each other at a spot a little posterior to the crystalline lens, and consequently falling at different angles on various points of the retina, no fixed and determined law can be promulgated concerning them.

Müller contends that erect vision consists only in the perception of the state of the retina itself, and not of any object placed anterior to it in the external world. He objects to the hypothesis of the "law of visible directions," and denies that the retina has an *outward* action, since there is no possibly apparent reason why one direction should have the preference to another; and if each ultimate sensitive portion of the retina had the power of action beyond itself, there would be produced as many directions as radii could be drawn from it to the external world. To use Müller's own words,[2] "If we do see objects inverted (or rather if the picture on the retina be inverted), the only proof we can possibly have of it is that afforded by the study of the laws of optics; and, if everything is seen reversed, the relative position of the objects remains unchanged. Hence, it is also that no discordance arises between the

[1] Volkman, On the Refractive Power of the Eye.

[2] Müller, On Erect Vision.

sensations of inverted vision and those of touch, which perceives everything in its erect position; for the images of all objects, even of our limbs, on the retina are equally inverted, and, therefore, maintain the same relative position. Even the image of our hands, when used in touch, is inverted."

The above quotation corresponds with the previously advanced ideas, by the writer, concerning the correlation of vision and touch. Now, it cannot positively be said that we perceive, or that the mind perceives, an image upon the retina; none but anatomists know it; for we are not conscious of its existence; *we perceive, or we see by means of this image.* Having thus premised, all difficulty seems banished, if this distinction be borne in mind. Why then, it may be asked, do we perceive an object in the upright position, when the image upon the retina is inverted? We see it in the upright position simply because it is inverted! This inversion is the necessary means of our so seeing the object.

Granting the above distinction, why is it that we do not judge of the object according to its sensible image? This is readily answered, since we have no knowledge or notion of *upright* or *inverted*, except such as is based upon experience; and, whatever be our standard of up and down, the sensible representation of *upright* will be an image upon the lower side of the retina, and of *downwards* just the reverse. The experience taught by the education of the senses in man, is intuitive or instinctive in animals. It seems to us that the various perplexities have arisen in consequence of the phenomenon of erect vision being produced by inverted images, or cubical and pyramidal, by means of an image upon the concavity of a sphere, or the perception of the many tinted colors of the rainbow upon a black surface. Well may the poet say :—

> "There is a voiceless eloquence on earth,
> Telling of Him who gave her wonders birth:
> Whose hidden but supreme control
> Moves through the world an universal soul.

The faculty of seeing objects single with two eyes, is very singular, and has occasioned much discussion. The fact is, that we are incapable of receiving two impressions from two images, but that, under certain, particular, and peculiar circumstances, one impression is formed of two. Each eye judges of the position of all objects directly within the field of vision. Now, when the two eyes are directed to any object, their axes meet in it, the two retinæ are opposite it, and all other points of the eye correspond mutu-

ally, in order to give the sensation of single vision. Therefore, when we look at a *distant* object, sufficiently far that the distance between the eyes becomes comparatively small, the two objects, being similar collections of forms, will coincide, if the corresponding points in both do likewise; this being the case, the double image of each object, falling upon corresponding points in the retina, becomes a single one.

Single vision from two images upon the retina is consequently but the result of an optical law, and it is a fallacy and mistaken notion to call in the aid of *habit* and experience to aid in its explication. For in ascribing single vision to experience, we necessarily infer an educational system of touch, or some such corresponding system, which is not true. Who would say that infants see everything double? Certainly no one, yet to prove such a doctrine, children would have to learn by experience that which they possess *per naturam*, and which would take a long time to be cognizant of. Another objection to such a theory is the simple fact that persons born blind, when restored to sight, *do not see double;* the only abnormal deviations being a lack in the power of adaptiveness with regard to perspective, etc. If two objects do not exactly coincide, the stronger impression absorbs the weaker, and the object is seen single. The writer has frequently verified this, by looking through two colored glasses at the same time, blue and dark red, and looking at objects (although he has no defect of vision whatsoever), he sees them red or blue, according as one or the other is before the right eye, the other color being before the left eye. This plainly shows how completely the mind takes cognizance of one impression to an unconscious exclusion of the other, when this impression is communicated by one organ of sense, exclusive of its fellow. The above phenomena were discovered by accident, whilst observing an eclipse of the sun. Exciting some surprise in the writer's mind, he prosecuted these experiments, and discovered, in every instance, that one eye was *stronger* than the other, or, in scientific application, that distinct impressions could be made upon one retina to the exclusion of the other. The conclusions drawn from these phenomena were such as to induce the following theory upon single vision: *Impressions are made upon both eyes at separate times, one following the other so rapidly that almost simultaneously an impression is conveyed by each to the sensorium, which reflects a double sensation, but one after another; and, in this manner, objects are seen singly, in consequence of a series, as it were, of sensations.*

The duration of an impression upon the retina varies. Mr. D'Arcy found that when a live coal was swung around a circle of 165 feet circumference, the impression remained a little longer than *one seventh of a second* upon the retina. Again, when a first impression is succeeded by a second in such rapidity that the latter runs into the other, the two, as it were, become one. This is readily demonstrated by whirling a piece of burning stick, which seems to be a complete circle of fire.

That the phenomena of single vision cannot be explained by the peculiar decussation of the optic nerve at the *chiasma* hardly any one will deny, when the important experiments and discoveries of Prof. Wheatstone concerning the *stereoscope* are entertained. These discoveries go to show that the mental interpretation of sensory impressions is a *modus operandi* not to be explained by any structural arrangements of the sensory apparatus, and that it is a process entirely foreign from any affection of the consciousness by such impressions.

According to Prof. Wheatstone, the perception of distance or perspective, and the idea of solidity, are evidently produced by the combination of two pictures of a solid body taken from either eye, as from two different points of sight. A singular and curious fact, which goes to prove this, is that a person with one eye, in viewing any solid body, is constantly moving his head from one side to the other; the result of which is, that he, by this means, gets with one eye the same effect that is obtained by two eyes with the head stationary. These conclusions, concisely drawn from the opinions of Prof. Wheatstone, are not as fully elaborated as the writer would desire; any further explanation either of the *stereoscope* or *pseudoscope* would be useless, as Prof. W. has two very learned and able articles upon them in the *Philosophical Transactions* for 1838 and 1852.

We now come to the consideration of the ophthalmoscope, and the revelations made by this most ingenious instrument. This discovery, as applied to the investigation of disease, is of modern date, and we owe it to Helmholtz, Professor of Physiology at Königsberg, Prussia. Mackenzie, of Scotland, however, applied a rudimentary ophthalmoscope in the investigation of diseases within the eye, previous to 1840, of which the particulars will be given farther on.

The power of seeing the interior of the eyes of such animals as the dog and the cat, which are deprived of pigmentum, depends.

not as many observers have supposed, upon nervous influence, but upon a reflection of the light from their eyes, which had passed therein from without. Prevost, in 1810, was the first to demonstrate this fact, and proved it by showing that no such effect was produced in a perfectly dark room. Gruithuisen[1] came to the same results, and added that the phenomenon was in part owing to an extraordinary refraction of the crystalline lens: he examined the eyes of many animals, living and dead, and his experiments were confirmed by Tiedemann,[1] Rudolph,[1] Müller,[1] Esser,[2] and Hassenstein.[3]

Hassenstein believed that the power of seeing within the eye was due to the muscular contraction of the globe in its antero-posterior diameter. Rudolphi considered that the eye should be turned in a certain direction in order that the phenomenon of oculoscopy might be made apparent. Beer[4] was among the first to observe the phenomenon in man, in a case of iridemia or congenital absence of the iris, where the patient suffered from a tumor upon the retina, and he remarked, that in order to see within the eye of the patient, the observer should look into it parallel to the luminous rays which fall upon it. Brücke[5] and Cumming[6] both gave the same directions, in order that the interior of the eye might be seen, yet they never once sought to discover there any diseased condition by such a procedure; they merely advised it as a method in which the chambers of the eye could be illuminated. Their experiments were about the same; and consisted in placing the subject in a darkened room, the observer holding a lamp or candle in one hand, and a screen in the other, the upper border of which is held upon a level with the flame, in such a manner as to prevent the rays of light from directly impinging upon his eyes: he looks over the top of the screen towards the pupil of the patient, who is some eight or ten feet in front of him, and who looks, as it were, out upon darkness. In this latter position the patient's pupils present a brilliantly lighted appearance of reddish-yellow color, which immediately become black if turned towards the light. The rationale of this experiment will be explained a little farther on. In the early part

[1] Zur vergleichenden Physiologie des Gesichtsinns. Leipzig, 1826.

[2] Kastner's Archiv. für die gesammte Naturlehre. Bd. viii. s. 399.

[3] De Luce ex quorundum animalium oculis prodeunte atque de tapeto lucido.

[4] Hecker's Annalen, t. i. s. 378, 1839.

[5] Müller, Archiv. für Anatomie und Physiologie, s. 225, 1847.

[6] Medico-Chirurgical Transactions, vol. xxix. p. 284.

of the eighteenth century, Mery[1] having accidentally plunged a cat into water, very unexpectedly beheld the bottom of the eye, and distinctly saw the bloodvessels thereon. He gave no explanation of the phenomenon, but reported the fact to the Academy of Sciences in Paris. In 1709, five years afterwards, La Hire[2] and Lattère[2] separately performed the same experiment, and both arrived at the same conclusion as to its explanation, viz., that we cannot see within the eye on account of the refractive power of the cornea and lens, whose normal refraction becomes neutralized by the action of the water, for the rays in passing out of the eye are divergent, but the water causes their convergence, and thus induces a focus to be brought upon the retina of the observer, and consequently an image there formed.

Kussmaul,[3] after having carefully studied the above described phenomena, repeated the experiments, and in 1845 published a monograph upon the subject. He demonstrated by dissection, that our inability to see the bottom of the eye is due to the refractive power of the cornea and lens. He took a sheep's eye and removed the cornea, and was still unable to see the retina: he then removed the lens, when all was visible, the transparent retina appeared with its bloodvessels, the papilla of the optic nerve stood out in bold relief, and the bright shining choroid glistened behind. Here was positive proof that the lens as well as the cornea exerted its influence upon the phenomenon in question, had we not previously known that the pupil still appears black after a successful operation for cataract.

The rationale of the experiments of Brucke and Cumming, quoted above, was not given until 1851, when Helmholtz[4] published his essay upon the ophthalmoscope. This distinguished *savan* explained the black color of the pupil by purely optical rules. Thus, the retina is not only transparent, but also reflects light, at least some rays which impinge upon it: these rays, in passing out of the eye, traverse the same media through which they entered, and come to a focus at the point of departure of the incident rays. The eye of the observer is too feeble to project sufficient light to illuminate the

[1] Ann. de l'Acad. des Sciences, 1704.

[2] Ibid., 1709.

[3] Die Farbenerscheinungen im Grunde des Menschlichen Auges, Heidelberg, 1845.

[4] Beschreibungeines Augenspiegel zur Beobachtung der Netzthaut in lebenden Auge, Berlin, 1851.

bottom of the eye explored, in order that the reflection there might throw an image upon the observer's retina.

From these propositions, the deduction is clear that, to see the retina of an individual, our own eye should be the luminous point, but our eye is too feeble to project a sufficient quantity of light to illuminate the eye explored—and as a consequence, in looking into an eye by the aid of ordinary daylight, our head would intercept the rays of light, necessary to the illumination; hence, being in the shade, the pupil would naturally appear to be dark and black. If the eye, on the contrary, instead of regarding a luminous point, is fixed upon a distant object, the rays reflected from the retina do not come to a focus at the point of departure of the incident rays, but beyond it; and, as these rays proceed in almost parallel bundles, a person placed anterior to the eye of the subject of the experiment, may easily perceive a portion of these rays. This is the rationale of Brüke's and of Cumming's experiments.

These facts led to the invention (not discovery) of the Ophthalmoscope of Helmholtz; for, upon the authority of Mr. Wharton Jones, Mr. Babbage has the priority of discovery. Mr. B. showed him an instrument in 1847, for the purpose of looking into the eye. It was made of a plain mirror, with the amalgam removed in two or three small spots in the centre; it was fixed in a tube at such an angle, that the rays of light falling upon it through the side of the tube, were reflected into the eye to be examined, to which one end of the tube was turned. The surgeon looked through the clear spots in the centre of the mirror, at the other end. This ophthalmoscope of Mr. Babbage was but the original of those of Graefe, Coccius, Donders, and Epkeus, and Meyerstein, which are but modifications of Helmholtz's. Helmholtz, although he introduced his ophthalmoscope four years later than did Mr. Babbage, is justly entitled to the distinction of being its inventor, as Mr. Babbage made no publication of his discovery. Reasoning upon the principles enunciated above, Helmholtz bethought himself of an artificial method of overcoming the insufficient reflection of the retina, or at least to devise some plan whereby the reflection from the retina would be so great, that the eye of the observer could, by being in the focus of the reflected rays, or at the point of departure of the incident rays, observe the bottom of the eye to be explored.

Von Erlach, who wore spectacles, observed one day, whilst con-

versing with a friend, that the sunlight was reflected from a neighboring window, upon his spectacles, and thence reflected into his friend's eye, very highly illuminating the pupil. He communicated this fact to Ruete and Helmholtz, and which undoubtedly led to the latter's using plate-glass reflectors in the ophthalmoscope which he invented in 1851. This instrument consists of a metallic tube or cylinder, painted black upon the inner surface; it is bevelled at one end to an angle of 56° to its axis; the other end is perfectly square, containing an eye-piece, composed of a diaphragm placed anteriorly to a bi-concave lens. Attached to the bevelled edge is a reflector of four highly polished and parallel pieces of glass.

The *modus operandi* of this *eye*-speculum is readily understood by referring to the annexed figure. The eye *B* looks into the eye *C*,

Fig. 8.

through *E*, consisting of a reflector, composed of four superposed glass plates, disposed at an angle of 56°, by which the light from *A* is reflected from it into the eye to be observed, *C*, in the same direction in which the observing eye looks. The eye *B* receives the reflected rays from *C*, converging so much, that the refractive

powers of the cornea, lens, and vitreous body, are not sufficiently strong to counteract; consequently, they do not come to a focus upon the observer's retina, thereby rendering him relatively myopic. To remedy this deficiency, Helmholtz introduced a bi-concave lens, which brings the rays to a focus upon the observer's retina, thereby producing an image of the internal structures of the eye, *C.*

Numerous ophthalmoscopes have been devised since the construction of Helmholtz's.

RUETE modified Helmholtz's by employing, instead of plate glass, a concave mirror (looking-glass), ten inches focus, having a small orifice in the centre, through which the surgeon looks into the patient's eye; a bi-convex lens is used to intensify the light.

COCCIUS'S instrument is a plain mirror, with a hole in the centre, and the light is concentrated upon it before it is reflected into the eye. Whenever either the surgeon or patient is myopic, a bi-concave lens is substituted to remedy the defect.

GRAEFE'S instrument is similar to the one claimed by the Greek surgeon, ANAGNOSTAKIS, as his invention. It consists of a concave mirror, of about two and a half inches in diameter, with a hole in the centre, through which the observer looks, the posterior surface of which is covered by a coating of blackened sheet copper; a bi-convex lens is used as in Coccius's. The writer, having read in Mackenzie's work on *Diseases of the Eye*, something concerning the claim of Anagnostakis to this instrument, whilst in Berlin, in the summer of 1857, made inquiries concerning it, and upon the authority of M. Lebrich, *chef de clinique* of Graefe, he learned that early in 1853, Graefe showed to the Athenian an instrument, the counterpart of the one described by him as being his own invention, the only difference being that Anagnostakis's is slightly the larger.

ULRICH'S is a similar one to Ruete's, but more compactly arranged.

FOLLIN AND NACHET'S is nothing more than Helmholtz's, with the addition of a bi-convex lens to condense the light, as it falls upon the reflector.

MEYERSTEIN'S is but a compact modification of Coccius's.

ZEHENDER'S is quite like Ulrich's, as is also HASMER'S.

DONDERS AND EPKENS'S instrument is a modification of Coccius's, the light being intensified as in Follin and Nachet's.

Desmarres's ophthalmoscope consists of a concave mirror of about 10 inches focus, constructed of burnished steel, with two small holes *near the circumference* on a line corresponding with its equator: the object of these two holes, is that the surgeon may use indiscriminately either the right or left eye. A bi-convex lens is used as in the application of Coccius's instrument. The writer prefers and uses Desmarres's instrument on account of its simplicity, and non-liability to get out of order: he also adds to it, a bi-concave glass to remedy myopia, when any such patient is examined (according to the method of Coccius).

Dixon's is upon the principle of Coccius, but is fixed in one of the rings of a spectacle frame: the other being balanced on the nose by a plane glass.

Jager's ophthalmoscope is said by many to be the most complete yet devised, but its complications are such, that when Desmarres's can possibly be used, it is by far the more preferable.

Thus having cursorily glanced at the various modifications of the ophthalmoscope without entering into their respective merits or demerits, it is deemed proper at once to enter into an account of the method of its use. As above stated, that of Desmarres is used by the writer, on account of its simplicity of construction and application: with it he proceeds as follows, always conducting the examination in a darkened room. The patient's pupil is at first dilated[1] by a solution of belladonna or atropia (neut. sulphat.); the writer prefers the atropine, and uses it in the proportion of one or two grains to the ounce of water. He places himself in front of the patient, seated preferably upon a music stool, as by so doing he can elevate or lower his position at will, which is a matter of no little importance.

A jet of gas covered by a glass shade, or an oil lamp, is placed to the left[2] of the patient upon a level with his eye, eight or nine inches from, and very slightly behind the head, in such a position as to have the eyes out of the immediate reflection of the light, and

[1] As to the dilatation of the pupil it is not necessary where the patient has an unusually large one, as in some cases of (so called) amaurosis. Frequently the healthy pupil is sufficiently large to allow of an ophthalmoscopical examination.

[2] With regard to the position of the light, whether it be to the left, or the right, or even above and behind the patient's head, is simply a matter of habit or convenience to the surgeon. The writer places the light to the left on account of custom, having first used the ophthalmoscope at the *cliniques* of the celebrated Desmarres, of Paris, where it is thus used.

in such a position as to receive the rays as propelled from the reflector of the ophthalmoscope. The surgeon then places his ophthalmoscope before either his right or left eye, the other being closed, and looks through one of the minute openings near its circumference, and causes the reflected light to fall upon the eye to be observed! A few manipulations with a bi-convex lens from 2½ to 4 inches focus will expose the internal arrangement of the eye. There are several important considerations to which attention must be given, before proceeding with the examination, viz., that the light be of sufficient intensity, that it be placed in a convenient position for the projection of the rays within the eye, that it be of varying intensity, and, that the patient be lower than the observer. Further on we will refer to the varying intensity of the light, as either the anterior or posterior portions of the inner eye are to be examined. After being properly arranged as regards position, light, etc., there still remain the greatest difficulties, viz., the bringing of the light to a focus so as to recognize the parts for which search is made. For the beginner this is extremely difficult: many and patient must be the sittings before he can acquire that degree of skill by which, at the first glance, he can immediately recognize the deep-seated structures, as there are certain very embarrassing obstacles to be overcome, such for instance as mistaking the image of the reflector for the papilla of the optic nerve. This obstacle with Desmarres's ophthalmoscope is easily remedied, as the two small holes near the circumference of the reflector appear as two minute black specks, which move in the same direction as the instrument is moved by the observer.

Another difficulty is the seeming impossibility of tracing the ramifications of any of the vessels, by neglecting to move the lens in an opposite direction from the point sought after. Again, the patient must keep his eye upon a fixed point, otherwise it is absolutely impossible to obtain the necessary reflection; and, all points to be examined should be placed as near as possible in a direct line corresponding to the axis of vision of the observer. Before introducing the lens, the reflection of the eye to be observed must be of a size corresponding to the reflector. The pupil at this stage presents a light yellowish-red color, like the tints of a summer's sunset cloud. The lens is now placed before the patient's eye, and, if properly adjusted, a most beautiful sight is revealed; but, if it be not properly adjusted, either the head of the observer, or the lens, or both must be moved slightly back-

wards or forwards, or laterally until a focus be obtained, when, if the eye examined be a healthy one, there will be displayed the

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The first thing sought for is the papilla of the optic nerve, as, from its peculiar characteristic appearances, it serves as a valuable landmark. In looking for the papilla it is well to trace the vessels, seen upon the reddish-white concavity of the retina, in the direction as they grow larger, when, a little below the equator and slightly within the axis of the eye, there will be seen a white shining circular spot of about four lines diameter, resembling the full moon in a clear sky. This papilla, which is nothing more than the termination of the optic nerve, slightly projects over the surrounding parts, thereby producing an apparent shading of the retina, but which truly is nothing more than the dark choroid seen shining through the transparent retina: this shading is known as the *periphery* of the papilla, and is generally surrounded by a slight grayish ring, composed of fine points of pigmentum resting upon the choroid. The dimensions of the papilla vary both in the living and the dead. Huschke came to the conclusion after many autopsies of healthy eyes, that it never exceeded one line in diameter. The mean diameter of over fifteen hundred reported ophthalmoscopical examinations of the papilla, as seen through a bi-convex lens, is 3½ lines. It frequently varies, more particularly with individuals affected with myopia and presbyopia. With short sighted individuals, when examined without the lens, the papilla seems to occupy the whole range of sight, if the pupil have not previously been dilated with atropine: if the lens be introduced then all appears just to the contrary, for the papilla appears much smaller than normal. In persons who are affected with presbyopia, the papilla without the lens seems very small, whereas the glass appears really to magnify it. From these apparent anomalies, it follows that in examining a short-sighted person, a lens decreasing in strength should be employed in a ratio as the myopia increases; and, with presbyopic individuals, the lens should be larger in proportion as the defect is more marked.[2]

[1] *Vide* Appendix, Figure I.

[2] Desmarres and Graefe advise the habitual use of the same lens in all examinations, as by it any abnormal appearance, however slight, can be the more readily appreciated, and the surgeon the more quickly see the necessity of using any other, such as the nature of the case might call for.

Springing from the papilla, but by no means always from its centre, is the *arteria centralis retinæ*, which frequently divides into four branches, two ascending and two descending, which go to form capillary loops throughout the whole of the retina, and then anastomose with the veins of the same name, which run nearly parallel to the arteries, and which pass out where the arteries enter. (*Vide* Fig. I., Appendix.) The veins are somewhat larger than the arteries, slightly more tortuous, and of a darker color. In cases of congestion of the retina, the writer has been able to count the pulsations of the arteries. Surrounding the papilla of the optic nerve is the *retina*, a transparent membrane, furrowed by bloodvessels, presenting a tint varying from a deep red to a pale rose color, and forming a concavity presenting anteriorly. The retina is of itself perfectly transparent, and the varying tints depend upon the color of the individual; hence, the color of the choroid. The retina would not be at all recognizable, were there no bloodvessels furrowing its surface. In Albinos, there being a diminution or even a complete want of pigmentum of the choroid, the retina appears to be of a pale rose tint, whereas in persons of a very dark complexion, negroes for instance, it is of a deep red, owing to the greater deposition of pigmentum in the choroid: with all individuals its color varies with the color of the skin.

The vessels of the retina, decreasing from behind forwards, towards the *ora serrata*, are but the continuation of the artery and the commencement of the vein, described above as springing from and entering the papilla. They present the general characteristics of color, size, and tortuosity, as veins and arteries most frequently do, only the former are more numerous than the latter. The yellow spot of Sœmmering, as seen by the ophthalmoscope, presents a brilliant yellowish appearance, with a depression in the centre, and is always found in the centre of the visual axis. Desmarres, from ophthalmoscopical observations, denies the existence of the *plica transversalis;* but it nevertheless exists, and is no *post-mortem* formation from shrinking of the retina. For, if the light be concentrated by a bi-convex lens upon the reflector, previous to its being thrown in the eye, it then becomes sufficiently intense, and the plica presents the same appearances as before described.

The *choroid* is readily recognized through the transparent retina, and presents a series of irregular blackish radiating striæ, arising from the circumference of the papilla of the optic nerve, and which

pursue a direction in lines of unequal length towards the *ora serrata:* about six lines posterior to this point they form a series of bifurcations, until lost within its substance. These striæ are formed by a deposit of pigment cells and granules, which are of a more intense color than the surrounding parts, as seen through the transparent retina. They have not been inaptly called the *choroidean arborisations*, and they vary in intensity in the same ratio as the choroid, which, as above mentioned, varies with the hue of the skin. In Albinos there is a complete absence of them: in the negro they are most beautifully developed. And so it varies in blonde and brunette, the one having blue eyes, fair hair and complexion, has less pigmentum; the other with a flashing eye, sparkling like the meteor of an August night, with hair as the raven's wing, and face as the olive's hue, possesses a choroid strongly charged with pigmentum. Between these *arborisations* there are seen patches of a beautiful rose tint, furrowed with the vessels of the retina. Having thus cursorily glanced at the normal condition of the eye, as seen by means of the ophthalmoscope, we are prepared to enter into a discussion of its utility as revealing diseased conditions, such as without its use would remain unknown, or at least without a diagnosis during life; and, whether the ophthalmoscope be of any benefit as to the therapeutics of impaired vision.

Prior to Helmholtz's discovery, there is but one case on record where the agency of external light was used in the investigation of diseases seated in the deep-seated structures,[1] and oculists were able

[1] In *Mackenzie's Practical Treatise*, p. 508, 1840, the following may be found: "I had under my care, at the Glasgow Eye Infirmary, a young man with incomplete amaurosis in each eye. His vision had failed suddenly about two years before. At that time it was subject to frequent alterations, becoming suddenly diminished, and as suddenly regaining its usual acuteness. He complained of headache, with painful sensations over the body. He was troubled with red spectra before the left eye, but not before the right. The left eye was presbyopic, but with the right eye he perceived near objects more distinctly than distant ones. Deep in the right vitreous humor, a spotted opaque appearance was observed. On dilating the pupil by belladonna, it was evident that there were two sets of opacities behind the lens. One, consisting of a central spot, with numerous opaque threads radiating from it, especially downwards and outwards, was situated exactly in the axis of the eye, and a little way behind the lens. The other opaque spot was much deeper in the eye, but without radii, and evidently moved up and down when the patient moved his eye. Each pupil possessed considerable power of motion, and there was no tremulousness of either iris. I considered the appearances in the right eye as indicative of inflammation of the hyaloid. In two subsequent cases, I have seen similar appearances. *In one of these I discovered what I*

to recognize only such diseases as were manifest to inspection, such as were seated upon the external parts of the eye, or anterior to the vitreous body, unless there existed some preternatural arrangement, as in Beer's case of congenital absence of the iris above mentioned. In rare instances some very expert diagnosticians observed a commencing cataract, but only after it had reached a comparatively considerable size, for the simple thin striæ recognized by the ophthalmoscope necessarily must have escaped the most rigid examination.

As to recognizing the pathological conditions of the deep-seated parts, all diagnoses had to be made *per exclusionem;* and in all treatises upon the eye, with regard to the subjects of amaurosis and amblyopia, page after page is filled with the subjective symptoms of diseased retina, optic nerve, and brain, as to the production of these diseases. Now, with regard to the discovery of the ophthalmoscope, it is for ophthalmology what auscultation and percussion are for the physical exploration of general diseases, which were at first feeble in their results, producing but meagre benefits, but are at present mighty as a giant oak, towering far above the other trees in the forest of medicine.

It is a principle of fundamental philosophy which holds good throughout the whole fabric of creation, that in order to remove an evil we must know its cause. It is upon this principle that therapeutics and diagnosis are based, and the former resting upon experience, begins where the latter ends, and when diagnosis fails there is no rational therapeutics: even empirical therapeutics loses all consideration if not based on sufficient differential diagnosis. A cure supervening upon any peculiar treatment, a question naturally arises, what has been cured? Hence, every assistance in the exploration of disease is a most welcome light in the search for truth, particularly when it renders us able to observe the changes in morbid structures, and associate them with functional derangements. Thus, it is with the ophthalmoscope! By it we are able to refer the evil to its cause, and boldly strike at its very root. Many, very many diseases of the eye, embraced under the head of

considered the effects of hyaloiditis on DIVERTING THE LIGHT OF A GAS JET THROUGH THE PUPIL WITH A LENS."

T. Wharton Jones, F. R. S., says: "Furthermore, Dr. Mackenzie tells me that by concentrating the daylight by means of a convex lens, he has seen red angular patches on the retina. The retina, when bulged forward and flapping in the dissolved vitreous humor, can be well seen."

nervous or *amaurotic* affections, whose nature was misunderstood, and whose treatment has led to many injudicious if not fatal consequences, have been proven by this instrument to be totally local, and not in the least referable to the brain. Take, for instance, an affection which has lately been discovered to have been frequently referred to a wrong cause, and consequently treated empirically and irrationally. We refer to *myodesopia* or *muscæ volitantes*, symptoms frequently met with in all kinds of medical practice. Yet, Mackenzie[1] devotes twenty pages to the consideration of this subject, dividing it into *sensitiva* and *insensitiva*, and again subdividing it into other heads, learnedly descanting upon the various forms as depending upon a variety of causes, proposing prognoses and treatments, fixing their causes in the brain, the optic nerve, retina, vitreous body, lens, cornea, and aqueous humor; and, still Mackenzie is about the highest authority we have upon the subject of eye diseases. Many hundreds, yea thousands of practitioners strictly follow him to the letter as regards treatment, etc., blindly following his directions, and urging onward the unhappy victim of misplaced confidence. Visions of cupping, bleeding, leeching, and purging, rise in ghastly array! Setons and blisters, fell caustics and rank poisons follow on, swelling the list in horrible numbers! Turn we away from the unhappy picture, and behold the brighter side! These formidable *muscæ*, which for years past have arisen from a mind diseased, are, by the ophthalmoscope, brought to their proper sphere, for Desmarres, Graefe, Donders, Arlt, and Van Trigt, have found that the greatest number of these cases were nothing more than a commencing cataract, or probably some floating particles in the vitreous body, or punctiform blood-spots, or an entozoon upon the retina, or a hopeless disease of the choroid, or an alteration in the papilla of the optic nerve. And all of these diseases deserve at least a different treatment, which is rather negative than otherwise; and, if the ophthalmoscope has not induced a curative treatment or beneficial therapeutics, it has at least saved many an unfortunate individual from an useless course of medicine. For who would treat any of these affections (save, perhaps, punctiform blood-spots upon the retina) in a constitutional manner? Certainly no one! Yet, reason and the severest inductive analysis would tell us to so do, as the seat of reason, "the dome of thought and palace of the soul," affect such symptoms when deranged; but, fortunately

[1] A Practical Treatise on the Diseases of the Eye, by William Mackenzie, M. D., loc. cit.

we call in the aid of a little yet mighty instrument, the ophthalmoscope, and see if the patient need the fearful array of implements necessary to beat down inflammation of the brain and its membranes, or whether the troubled mind of a fellow being can be alleviated by the sweet assurance that he is not vitally hurt, and that useless medication need not be persisted in, as it is a sure precursor to after-constitutional diseases. The same remarks are pertinent to various other affections of the eye, as brain diseases present all the symptoms which are also met with in *extra-cerebral* diseases of the inner portions of the eye. Such, for instance, as the appearance of a black cloud hiding a portion, if not the whole of objects from the vision of the patient, or a crossing myopia, which is the apparent crossing of objects seen at a little distance. The ophthalmoscope has discovered the latter symptom to be due to a *posterior sclero-choroiditis*, and the former to a variety of pathological conditions, more particularly, however, to a *detachment of the retina.* Yet, how many treat these diseases empirically, not knowing what they do, and still at the same time are high-minded, honorable, and conscientious physicians. These lamentable facts are but stronger reasons why we should hasten to avail ourselves of every means of physical exploration, as applicable to the cure of disease, and of alleviating suffering humanity, advancing our science to a rapidly approaching perfection, and thereby promoting the moral tone, the honor, and the ability of the profession, so that each individual may become an ornament to society, a healthful member of the body politic, and by his integrity let it be said of him, *dux hominum medicus est.*

As above mentioned, one of the greatest advantages which the ophthalmoscope offers, is the ready recognition of *cerebral* and *extra-cerebral* amaurosis (so called), for a physical exploration of the eye immediately reveals whether or not it be the seat of disease or of derangement.

With one who is skilled in the ophthalmoscopic art, how easy it is to save the willing patient from "a course of mercury," holding out as hopeful a hopeless termination. One of the first principles of the *morale* of the science of medicine is to alleviate, not to harm. We shudder to think of the baneful errors committed in the name of medicine, and yet would be the last to say that they were knowingly so done, hence we grasp with avidity all diagnostic helps, and cry out with thanks to their inventors. Humanity thanks Helmholtz, medicine honors him, and charity lauds him as a benefactor!

Who would, possessing ophthalmoscopic knowledge, treat *sparkling synchisis* of the vitreous body, formative cataract *striæ* of the lens, *muscæ volitantes* arising from entohyaloid bodies, and a thousand and one other amblyopias with mercury? No one of conscience, yet we do it, promising a cure to the patient, at the same time defibrinating him, entailing untold miseries upon him and his offspring unborn. Ay, frequently does the physician, from an incorrect diagnosis, become the instrument of the revelation of the prophecy, that the sins of the father shall descend to his children, even unto the third generation. Witness the various statistical reports of surgical operations throughout the whole of the civilized world, and there count how many are attributed to mercury! Do not think that we decry mercury, far from it, we look upon it as one of the most useful remedies in the whole pharmacopœia, yet when unskilfully and wrongly used, it becomes as fire in a powder magazine. Thus, much of the unskilful application of mercury may be avoided by a judicious use of the little yet mighty ophthalmoscope!

Henceforth the words "amaurosis" and "amblyopia" may be expelled from the dignified positions which they formerly held in the category of diseases, and always known as symptoms only, of the numerous affections recognized by the potent instrument in question. Amaurosis and amblyopia may be considered symptomatic of cerebral disease; of hyperæmia, anæmia, atrophy and hypertrophy of the papilla of the optic nerve; of detachment, œdema, inflammation, congestion and apoplexy of the retina; in fact of the various pathological conditions which will be sketched further on. Included among the primary results above mentioned, to the pathologist, accruing from the use of the instrument, there are also many secondary beneficial results which assist the surgeon, as to the propriety of operating for the various diseases requiring such interference.

We are now prepared to enter upon the consideration of some of the anomalies of vision as revealed by the ophthalmoscope, or rather to sketch the pathological conditions of the various parts of the eye as seen by means of this instrument which constitute the

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Omitting the diseases of the cornea and the aqueous humor, together with the entozoa found there, we proceed to glance at the affections of the

Crystalline Lens.—The most frequent diseases of this body are what are known as lenticular and capsular cataracts, and at certain stages of development are readily recognized without any aid to the naked eye. Frequently, however, the surgeon is consulted at a very early stage in the progress of the disease, and a judicious examination may save the patient a considerable degree of useless medication for *muscæ volitantes.* At this stage the surgeon will see (after having well dilated the pupil with atropine, and using a light, less intense than such as is used to explore the deeper structures) delicate *cataract striæ*, either in the centre or upon the circumference.

The method of detecting the seat of these striæ is the result of a *per exclusioneum* reasoning. The patient is directed to turn his eye upwards, and the streak upon the posterior portion either of the capsule or lens, instead of being dragged upwards as if it were on the anterior surface, is on the contrary depressed from its pre-observed situation, so much so that it becomes hidden behind the inferior segment of the iris. If the patient looks downwards, the reverse of this takes place. The catoptrical test of Purkinje answers very well for all cataracts after a certain period of development, but it cannot demonstrate as does the ophthalmoscope, the formative stages, such as the striæ above mentioned, the presence of a very slight false membrane, or of pigmentary cataract, which consists in the deposition of pigment granules within the substance of the lens, which, according to Desmarres, constitutes more than 30 per cent. of so called *muscæ volitantes.* Anæmia of the choroid is most generally associated with opacity of the lens, for vision does not solely depend upon the amount of light, but frequently upon the quantity of blood in the various tunics; and, the greater the amount of blood, less than congestion, the better the sight, owing to the relation between all parts of the eye. To observe the affections of the *vitreous body*, the use of the bi-convex lens may be dispensed with. The most frequently observed affections of this medium are *sanguineous effusions*, *floating bodies*, *glistening or sparkling synchisis*, and *urinoid turbidity.*

A. Sanguineous effusions are most frequently the result of a rupture of the vessels of the retina, or a sub-retinal apoplexy producing a rupture of that tunic, thereby permitting the blood to be effused within the substance of the vitreous body. Farther on we propose to give the differential diagnosis between an effusion of blood within this medium and a sub-retinal effusion.

B. Floating bodies are free and mobile, of variable forms and

dimensions, most generally seen as minute corpuscles. These corpuscles are either the *débris* of a sanguineous effusion, or are fibrino-albuminous exudations the results of a previous inflammation, and appear black in consequence of the absorption of the refracted light. Perhaps these corpuscles are the combined results of all of the above mentioned causes. However, whatever be their nature, they are seen flying about, as it were, within the vitreous body when the eye is in motion, appearing and disappearing at each moment. These floating bodies are generally connected with a preternatural fluidity of the vitreous. What is the normal fluidity of the vitreous has not as yet been determined; and, in a healthy eye, no mobility or fluidity can be perceived. In the majority of cases where these floating bodies have been observed with fluidity of the vitreous, it was referable to some antecedent syphilitic taint. These corpuscles may sometimes be confounded with cataract-striæ of the lens, but a little attention may prevent such an error. Thus, if the patient be told to look alternately upon two fixed points the cataract-striæ will be seen to be moving always in the same direction, but if the abnormal products be corpuscular floating bodies, they will be seen swimming about in various directions, never the same.

Sometimes the papilla of the optic nerve, in short-sighted individuals, is mistaken for a free foreign body within the vitreous. This may be detected by using a bi-convex lens, and causing the patient to execute slow lateral movements of the eye, when the assumed foreign body will be seen to be moving always in the same direction, possessing the uniform silvery white color, characteristic of the entrance of the optic nerve. Sometimes these floating substances assume an arachnoid appearance, having either free or attached borders, sometimes both. Again, they may be one or two, or several distinct masses of shreddy gray exudation-plasma, and may even hang pendant like a curtain. This complication affects vision less than do many small bodies moving about in all directions. Another complication is,

c. Glistening synchisis (Σύγχυσις, from συγχύω, I mingle), which consists of the presence of a number of small scales or crystals of cholesterin. Desmarres was the first to describe this affection, and he observed it to be frequently complicated with other floating bodies. When the complication exists, an ophthalmoscopical examination reveals a most beautiful sight, for the glittering cholesterin scales, by their reflection, act upon the other bodies, giving them

the most brilliant hues of the rainbow, and the scales themselves present a more beautiful exhibition of natural pyrotechnics than artifice can possibly devise.

D. The last form of floating bodies consists in an *urinoid turbidity*[1] of the vitreous humor. Desmarres reports the only cases on record of this affection, which consists of a more or less notable quantity of microscopical corpuscles, giving the vitreous the appearance of the urine of herbivorous animals. These corpuscles are composed of an albumino-fibrinous exudation, the result of a previous inflammation.

As to the treatment of these various affections of the vitreous body, it consists in the prevention of medication: it would be just as probable to see a man's head absorbed as many of these floating bodies.

The diseases recognized by an ophthalmoscopical examination of the *retina* are either *simple* or *complicated*, that is to say, they are seated in the retina only, or extend to other structures. We propose noticing the *simple* ones only: the *complicated* ones will be described when the affections of the other structures are entertained. The *simple* diseases are *œdema*, *anæmia*, *hyperæmia*, *separation* or *detachment*, and *apoplexy*.

Œdema is the result of a sub-retinal serous infiltration, referable to some obstruction of the circulation, either mechanical or otherwise. The ophthalmoscope reveals a swelling, circular in form, surrounding the papilla of the optic nerve, somewhat raised above the other parts of the membrane, and whitish in color, with very minute punctiform blood-spots scattered through it. This œdema is sometimes associated with sub-retinal apoplexy, and is frequently seen when there is either papillary or retinal hyperæmia, or both. Desmarres frequently diagnosticates *morbus Brightii*, or at least suspects it, when there is considerable amblyopia and other concomitant constitutional symptoms, and when *œdema retinæ* is revealed by the ophthalmoscope. We have frequently seen the French oculist detect albumen in the urine of such patients. Donders, of Utrecht, has likewise observed the same pathological changes in the retina, and upon several *post-mortem* examinations he has de-

[1] Desmarres calls this condition, *etat jumenteux du corps vitré:* as there is no word in English corresponding to *jumenteux*, an adjective from the substantive *jument*, a mare, we metonomyze, as it were, a translation, and render it "urinoid turbidity," as the urine of the mare, as well as of all herbivorous animals, is more or less turbid.

tected fat globules deposited therein: hence, he called œdema of the retina, attendant upon *morbus Brightii*, *fatty degeneration of the retina*. The treatment, as a consequence, is necessarily *ad expectandum*, and must be followed upon general principles. In albuminuria—the writer has seen several cases (one in Paris and three in the United States), wherein an ophthalmoscopical examination revealed a deposition of pigmentum between the forks or divisions of the vessels upon the retina. (*Vide* Appendix, Fig. X.)

Anæmia retinæ is a consequence (most generally) of a constitutional anæmia, or it may be partial and dependent upon some local cause. The ophthalmoscope reveals a general paleness, either of the whole retina or of a part, as either one or the other is affected, and in proportion as is the anæmia so is the pallor: the vessels are smaller than normal, so small sometimes as to appear perfectly empty, and the arterial pulsations cannot be detected. The affection is characterized by more or less amblyopia, and sometimes by a complete amaurosis. The treatment is by tonics, more especially the chalybeates, fresh air, generous diet, etc. The patient should be particularly guarded against using his eyes in such a manner as to overtask them: the writer has frequently seen incurable anæmic congestions of the retina result from such imprudences.

Hyperæmia retinæ (Fig. XI., Appendix) is the most common of all intra-ocular lesions, and at the *cliniques* of Desmarres and Sichel, in Paris, and the *Augenklinik* of Graefe, of Berlin, hundreds of patients thus affected present themselves during the year. One half of the ophthalmoscopical observations noted in Desmarres's case-book indicate this lesion: during a three months' course there, the writer has notes of over forty such cases, the majority of whom were women who sewed for a livelihood, and the others were made up of artisans whose labor required a considerable degree of fixedness of sight upon small objects, such as engravers, printers, instrument and watchmakers, jewellers, etc. etc. There also were glass-blowers, cooks, bakers, etc., who are particularly prone to all intra-ocular diseases from the varying intensity of heat and light to which they are subjected. The second category embraces those, whose amblyopia is readily explained by a mechanico-physiological over-use of the eye; whereas the first class and by far the greatest number of amblyopics are sewing-girls, tailors, etc., who, to the causes pertinent to the second class, have added a sedentary life, close and heated rooms, everything in fact tending to a cachectic disposition or habit, inducing local hyperæmias, congestions, and in-

flammations; and the retina is by election, as it were, the most frequent seat of such changes in the eye, in the quantity and quality of the blood.

The ophthalmoscope reveals a turgidity of all the vessels, a marked injection of the veins in particular, of which there is a fresh crop developed by the increase and dilatation of the capillaries. The retina proper loses, in a measure, its brilliant transparency, and becomes of a deeper red, and looks drier than normally. The most frequent complication is a hyperæmia of the papilla of the optic nerve, of which more anon.

Were it not for the ophthalmoscope this affection would not be recognized (at least by any external evidence), for at first the symptomatic amblyopia is but slight, and it is here that therapeutics come to the rescue, and save perhaps an ulterior destruction of the functions of vision. A proper and judicious course of mercury, joined to other antiphlogistic remedies, at this stage is of the first importance; but, if the hyperæmia should have gone beyond, to a condition of apoplexy or of detachment of the retina, then, as before mentioned, mercury is but an useless and baneful remedy. Other frequent complications are, the *œdema* above noticed, *hyperæmia of the choroid*, *sub-retinal apoplexy*, *atrophy of the papilla*, and *posterior sclero-choroiditis.*

Detachment of the retina from superjacent parts is an affection of more frequent occurrence than is generally supposed; yet some of the latest writers on the subject of the diseases of the eye hardly more than refer to it. Mackenzie indicates such an affection, Nélaton[1] describes it only when it has reached such a degree of severity, that the whole retina is floating in the vitreous humor, so as to be readily recognized behind the lens: he advises the method of Mr. Ware, of making an exploratory puncture, to see if this foreign floating body really be a cataract or not. Desmarres,[2] in his first edition, gave a more detailed description of the affection, but like Nélaton he spoke only of such cases as were easily appreciated by the surgeon's eye alone. At present, all of the European oculists use the ophthalmoscope, as being absolutely necessary to recognize with precision such a pathological condition of the retina as a detachment would present. For, as above mentioned, when speaking of the utility of the instrument, we noticed the benefits accruing from an early recognition of any intra-ocular lesion whatsoever, and

[1] Nélaton, Elements de Patholog. Chirurg., t. iii. p. 212.

[2] Desmarres, Traité Théor. et Prat. des Maladies des Yeux, p. 710.

at present, in considering a disease, the ulterior termination of which is a certain destruction of sight, it is of the greatest importance to diagnosticate it at the very beginning. For, according to Desmarres and others, an early diagnosis of the disease sometimes brings about a cure, and judicious treatment may induce an absorption of either the serum or blood effused which produces the disease, and this being done, the retina recovers its healthy tone.

The rational symptoms generally come on in a regular order: the patient at first perceives luminous images as a result of the compression made upon the retina by the effusion. These images frequently affect the various colors of the prism; sometimes they are seen as through a colored veil, of a relative and proportional size corresponding to the effusion. Later the patient is struck with sudden blindness, all before him appears as black as night, or, if not so complete as total blindness, a dark cloud screens a portion of objects within his field of vision. In some instances he can trace the shape of the screen, which corresponds to the effusion upon the retina (in shape), as seen by the ophthalmoscope. The *phosphènes* before mentioned are recognizable if there be not complete anæsthesia of the retina, and as is the seat of these luminous rings, so is the chance of a recovery of complete vision, provided the absorption of the effusion can be induced.

There are two kinds of retinal detachments, referable to the effusion of either serum or blood. *Physical or ophthalmoscopical symptoms.* In order to recognize these detachments, it is not always absolutely necessary to use the bi-convex lens, and when the detached portion is seen, it is well to cause the patient to execute rapidly certain lateral and vertical movements of the eye, when the tumor will be recognized.

A. Detachment as a result of a serous effusion. The base of the eye presents a tumor of a whitish, or bluish, or grayish, or even reddish color, of a variable form and dimension: the tumor presents some red lines, which are the vessels of the retina furrowing it even in its abnormal projection beyond its natural plane. Sometimes the retina is of a dull white color, presenting the appearance of a false membrane, but the presence of the vessels and the suddenness of the attack would preclude such a supposition. Upon a careful examination the detached portion may be seen floating in the vitreous humor, and with a bi-convex lens the line of separation, between the detached tumor and the retina in its place, may readily be traced by fixing one of the vessels, and following its

course until it suddenly bends, as it were, upon itself. Having thus done, the tumor presents itself frequently as an opaque body, not glistening and shining as does the normal and healthy retina lying in its proper position. This condition may be complicated with any or all of the other intra-ocular diseases.

B. Detachment as the result of a sanguineous effusion, or sub-retinal apoplexy. The rational symptoms are pretty much the same as in detachments, the results of serous infiltration, with this difference, that they are more sudden. The cause is a rupture of one or more of the swollen, turgid, or diseased vessels of the choroid, happening most frequently in that pathological condition denominated by Graefe, of Berlin, as *posterior sclero-choroiditis.* A sudden rupture of a vessel behind the retina, rolls this tunic (by the accumulation of blood between it and the choroid), forward into the vitreous humor. An ophthalmoscopical examination reveals, in such an instance, a tumor of a deep red color, formed by the prominent retina; the blood itself may be seen through its walls, the retinal vessels are seen furrowing it, and trembling, as does the mass, when the movements of the eye are communicated to it. The conditions of the parts do not always thus remain; frequently the effusion is much increased, so much as to interfere with the nutrition of the retina, in such a manner as to produce its entire absorption in one, or several spots, or its bursting or rupturing, causing an effusion of blood into the vitreous humor, where, later, it forms one species of foreign bodies above mentioned. Sometimes these effusions do not produce a tumor, but are extravasated under the retina, and pass forward to be evacuated, as it were, from the *ora serrata*, to be adapted to the *fossa hyaloidea*, presenting a concavity, as if the whole vitreous humor were completely filled with blood. The fixedness, however, of this concavity precludes its being within the vitreous, as all foreign bodies partake more or less of the mobility of that body. Desmarres, after many ophthalmoscopical examinations, has discovered a new rational symptom, which is still a physical sign of sub-retinal sanguineous effusions, viz., a preservation of all the characteristics of the iris, save its color, which becomes of a dirty green color, owing to an overdue compression exercised by the effused blood. These effusions frequently undergo variations of color, being at first of a deep red, then of a light pink, afterwards of a muddy yellow, and finally gray; these transformations in color being nothing more than the usual changes undergone by subserous effusions of blood. When

these effusions are not, or are only partially absorbed, an inflammation is set up around, exudative most generally in its character, and false membranes are formed; a choroiditis ensues, followed by a maceration of the pigmentum, inducing most serious and incurable derangements in the functions of vision. As in serous effusions, relapses from a partial cure of sanguineous effusions are not perceived by the patient, who, *nolens volens*, becomes totally amaurotic, applies to an oculist not using the ophthalmoscope, is put upon a "course of mercury," undergoes that treatment for six months or more, and finishes disgusted, defibrinated, shattered in constitution, low in spirits, and not so well in health as when he commenced!

Apoplexy of the retina is an effusion of blood into the substance proper of the retina. It is extremely rare, and but few cases of it are on record. The rational symptoms are those of sub-retinal apoplexy, or detachment of that structure from sanguineous effusions, with the exception of being sudden and more complete. The physical or ophthalmoscopical signs are, a normal and healthy appearance of the transparent media (the cornea, aqueous and vitreous humors, and crystalline lens); the retina is completely discolored, the optic nerve and macula lutea invisible; the position of the former is only recognizable by the ruptured vessels being there traced. Numerous clots are seen hanging upon the coats of the vessels, and projecting into the vitreous body. Liebrich[1] has detailed a very interesting case of apoplexy of the retina, but space will not permit of its being quoted.

The papilla of the optic nerve is subject to various alterations, discovered by the ophthalmoscope; viz., *hyperæmia*, *anæmia*, *hypertrophy*, *atrophy*, and *prominence*.

With regard to the exploration of the diseases of the papilla, a bi-convex lens is absolutely indispensable. The rational symptoms are altogether negative, indicating nothing more than possibly can be attributed to other intra-ocular lesions. The physical signs are such that, by an ophthalmoscopical examination, an early diagnosis may be made, a judicious treatment given, and a cure effected.

Hyperæmia papilla. (*Vide* Fig. XI., Appendix.) The ophthalmoscope reveals in this pathological condition, a loss of the bright shining whiteness of the normal papilla, which, from an over-development of the vessels, becomes red, varying from a rose-pink tint, to the deepest scarlet. In the less serious congestions, the color is of a light pink, and the papilla is seen as through a gauze

[1] Archiv. Ophth. Graefe, Donders und Arlt, B. I. s. ii. p. 346.

veil; but, in the more serious ones, it is completely hidden by the numerous distended vessels, and its position is only known by the fact, that the vessels spring from, and enter about its centre. In some few cases, however, a small portion of the papilla may be seen through the network of vessels covering it; in others, the vessels surround it in such a manner as to make it appear as if it were scooped out, not unlike the cornea in *chemosis conjunctivæ.* Sometimes the veins are so turgid, that they present a varicose condition, constituting what is known as *varix papillæ*, and *varix retinæ*, by no means rare affections, and readily recognized by pressure upon the ocular globe, which produces a prominence of the vessels, whereby their pulsations may be made visible.

If the disease be attacked before exudations have formed, it generally yields to general and local antiphlogistic measures ; but, if the plasma should have done its work, the masonry of nature is not often removed from the spot upon which it has been deposited by the *vis medicatrix.* The exudations consecutive upon a hyperæmia are the real causes which induce a blindness, and in such cases a course of mercury is warrantable, but fails more frequently than otherwise, not from the non-absorbability but from the various relapses, for after one hyperæmia of any portion of the intra-ocular structure there is a tendency to another: the eye, in fact, is in the condition of an exudative crasis, viz: that condition which Rokitansky describes, when the system has a tendency to any peculiar lesion, such as the pneumonic crasis, the febrile crasis, etc. etc.

Always, when there is hyperæmia of the papilla, there is a like condition of the retina; but the latter's being thus affected does not necessarily imply such a one of the former. All of the other intra-ocular lesions before described may be, and sometimes are associated with hyperæmia of the papilla.

Anæmia papillæ is a condition quite the reverse of the preceding, and is characterized by a diminution in the calibre of the vessels, or even their complete absence. The normal color is absent, and there is a marked paleness in the whole of the surrounding structures. Anæmia of the retina is attendant upon anæmia of the papilla, and *vice versâ.*

Hypertrophia papillæ has been observed but once, at least there is only one case on record,[1] and in this case the conditions of the apparatus of vision were healthy, save an increase in the size of

[1] Medico Chirurgical Review, April, 1855, p. 386.

the papilla, its diameter being about seven lines. "The patient, who was a vigorous man, without any known cause had lost all sensibility to light."

Atrophia papillæ is totally the reverse of the last-named affection, and is a disease known only since the discovery of the ophthalmoscope. It is an infallible symptom of cerebral affection, and the amaurosis which it entails is altogether organic, dependent upon some interference with the nutrition of the optic nerve. In such a condition the ophthalmoscope reveals a most marked diminution in the size of the papilla, which seems shrunk and shrivelled. The retina also partakes slightly of this shrivelled appearance. This atrophy is nothing more or less than a paralysis of the nerve, which may be complete or incomplete. The treatment of this lesion depends upon the cause, and all therapeutics must be directed towards it. It may be congestion, inflammation, tuberculosis, ramollissement, the presence of a tumor, in fact any disease of the brain; and to the treatment of the cause the result of the amaurosis must tend.

Prominence of the papilla is one of the gravest of affections, and as it is beyond the resources of therapeutics or surgery, it is well to be able to diagnosticate it from the beginning, for many reasons above mentioned. The ophthalmoscope shows a shaded ring all around the papillary circumference, owing to its overhanging the choroid. The bloodvessels, which in the normal condition proceed in rather direct lines from the centre of the papilla, in this condition, after reaching its circumference, are bent down, and completely hidden under the margin; they are so abruptly bent as to give the appearance of having been cut away: a line or so from the margin they make their reappearance. Prominence of the papilla is most generally associated with posterior sclero-choroiditis, although the latter is not always met with in conjunction with the former: hyperæmia and anæmia are not unfrequently associated with it. In fact all of the intra-ocular lesions are so apt to be blended together, that it is rather a rarity than otherwise to find a purely uncomplicated case of a lesion of any one of the internal structures of the eye.

The pathological conditions of the choroid, as revealed by the ophthalmoscope, constitute some of the most interesting discoveries in ophthalmology, and the researches instituted by modern investigators upon the subject are worthy the attention not only of the oculist, but of the general pathologist. The affections of the cho-

roid, as classified by the latest authorities, are *choroiditis, and posterior sclero-choroiditis.*

Choroiditis is acute and chronic. The symptoms by which acute choroiditis was recognized prior to the discovery of the ophthalmoscope, or the indications furnished by an inspection of the external portions of the globe were (and are now) as follows: The patient complains of a severe shooting and pulsating pain within the eye and the surrounding parts on that side of the head: this pain intermits, and is very much exaggerated during the night. Photophobia is one of the earliest and most constant symptoms, as well as excessive lachrymation. Photopsia or spontaneous flashes of light are frequent, for the patient complains of such flashes of brilliant yellowish and reddish light, even when in obscurity. All motions, either of the eyeball or of the body, are attended with acute pain. The ocular globe, felt through the lids, is as hard as rock, and the slightest touch thereon produces violent pain. If it be possible to obtain a view of the eye in such a condition, the sub-conjunctival and sclerotical vessels are found to be slightly injected, the larger exterior vessels anastomosing around the cornea, and (according to Mackenzie) are in a state of passive congestion. The whole white of the eye presents a dirty yellowish aspect. The cornea is frequently cloudy and hazy, and sometimes rough, and the edge presents a milky bluish aspect, owing to the overlapping of the sclerotica. The iris is at first in a state of contraction, presenting a dirty green color, but soon assumes a slate color, and is permanently dilated, often misshapen and ragged. In acute choroiditis the ophthalmoscope reveals a great deal, but to make a thorough examination it is absolutely necessary to chloroform the patient, as the involuntary contraction of the palpebral muscles, and the intense photophobia, render it impossible without the aid of anæsthetics. The retina rarely, if ever, escapes being complicated with the inflamed choroid; hence, in an ophthalmoscopical examination the appearances are pretty much the same as in retinitis or hyperæmia of the retina, with the exception of a very peculiar rolling, as it were, of the pigmentum into irregular bundles, which completely destroys the before-mentioned radiated arrangement of that substance. The treatment in these instances requires the most active antiphlogistic measures and regimen, conjoined with opiates, and an excito-secretory expectant use of remedies.

The *non-ophthalmoscopical symptoms of chronic choroiditis*, such as are furnished by the feelings of the patient, and an examination of the external tunics of the eye, are as follows: The lesion makes its appearance slowly and step by step: a dull heavy pain is felt in the eye and circumorbital regions, photopsia, slight photophobia, and iridescent vision daily become of a more alarming character. The sub-conjunctival vessels are injected, and become very tortuous and varicose, the iris loses its normal appearance and assumes a dirty lead color. Later the sclerotic becomes thinner by interstitial absorption, and presents a blue or even dark color: in certain spots it is much thinner than the surrounding tissue, and the choroid bulges forward, forming incomplete hernias of that membrane, true (so called) posterior staphyloma of the choroid. The eyeball becomes harder as the disease advances, which is just the reverse of what takes place in acute chronic retinitis. To sum up in a few words, the symptoms offered by chronic choroiditis, are the same as in acute choroiditis, being, however, of a milder type.

Conditions of the Parts in Chronic Choroiditis as seen by the Ophthalmoscope.—After having examined the transparent media, as should always be done prior to the deep research, the entrance of the optic nerve is sought for, as well as the yellow spot of Sœmmering, which being found, the rest of the examination is made with a greater degree of certainty. And as the congestion or inflammation is of an active or passive character, so are the appearances presented by the parts, more particularly as regards the bloodvessels than the other structures. In an active or sthenic congestion the choroid is of a very bright red color, approaching to a vermilion or scarlet tint—the arteries and veins upon the retina numerous, following the normal disposition and maintaining their normal size. The transparent media assume a very brilliant appearance, owing to the momentum of the red rays of light: frequently the lens is affected with undulating and transverse striæ, which are not cataract-striæ, as they disappear if the choroiditis be ameliorated. There is always a slight maceration of the pigmentum in this form of choroiditis. In the passive or asthenic condition, the choroid is of a dirty dark red, approaching to a leaden hue, and is covered by numerous spots of brownish red pigmentum. Upon the retina numerous swollen, turgid and tortuous veins are seen, whereas there are very few small and thin arteries. The crystalline lens and vitreous body are muddy, often glaucomatous, and in the latter, shreds of detached retina and pigment cells are seen floating. These pigment cells

floating in the vitreous body constitute one of the characters of *maceration of the pigmentum.*

This condition is readily understood by its name: it consists of a detachment of a greater or less quantity of pigmentum, and a derangement of the normal radiated appearance of that substance: there is a certain quantity rolled as it were upon itself, which presents a brownish black appearance with ragged edges. Wherever there is a detachment of this pigment, the white sclerotic is seen through the somewhat hazy retina, presenting white patches which reflect the light. This maceration of the pigmentum at once explains the photopsia and other peculiar symptoms with regard to deranged sensation, as referred by the patient. Thus a confusion of images is explained by there being a reflection of light from the retina, which has no pigmentum behind it to absorb a superabundance of the luminous rays, which are reflected in various ways upon different parts of the retina, thereby producing a confusion of images. Again where the pigmentum is detached as in the last instance, the retina is extremely sensitive, and is affected by a very moderate light, hence the photopsia and iridescent vision. This exquisite sensitiveness of the retina, finishes by a complete anæsthesia of such parts as are deprived of pigmentum. One of the most dreaded results of a lesion of the choroid is an exudative inflammation, which explains the anæsthesia in question; for, wherever there is a maceration of the pigmentum, the exudation takes place, as it were, by election, and pressing upon the retina from behind, causes it to bulge forward into the vitreous body. This pressure being constant, generally ends by a complete change in the structure of the retina, causing it to become opaque or hazy from an effusion of lymph, or the contrary takes place and the retina bursts, allowing the pigment granules and cells to enter the substance of the vitreous body. This latter complication is more frequently met with in passive or asthenic inflammation than in the other conditions of active or sthenic choroiditis. The explanation of the entrance of these pigment particles into the vitreous body, at once accounts for the *muscæ volitantes* so frequently met with, as symptomatic of *diseased brain*, and which, combined with the other symptoms of choroiditis would lead us to anticipate a lesion rather more fatal to life than eye disease. It is very, nay absolutely necessary, in choroiditis to use the ophthalmoscope in the formation of a diagnosis and prognosis; and, it would be useless for us to reiterate what we have frequently before advanced,

viz., the baneful results of a mistaken diagnosis, and of the misapprehension of brain disease for eye disease, and *vice versa.* There yet remains to be described an affection, which, in point of frequency of occurrence, and interest to the special and general pathologist, is worthy of the greatest attention, viz :—

Posterior Sclero-choroiditis.—Graefe,[1] of Berlin, was the first to call attention to this disease, and as such deserves the thanks of the profession, not only for his Herculean labors in this field, but also for his manifold works in the ophthalmological science. His statistics, with regard to the disease in question, have been confirmed by Arlt, of Prague, Donders, of Utrecht, and Desmarres, of Paris. Graefe found that out of one thousand cases of so-called amblyopia, four hundred and twenty (42 per cent.) were connected with a posterior sclero-choroiditis. Another remarkable point in connection with the disease, is that short-sighted persons more particularly labor under this disease than any other class. Graefe states that myopics who use concave glasses ranging from two to six (German enumeration), nine out of every ten (90 per cent.) possess this lesion. The writer would state that he saw many such cases at the *cliniques* of Desmarres, and all, with but one exception, were myopic. Since the discovery of the disease by the ophthalmoscope, we are enabled, without this instrument, to at least suspect the presence of the disease through subjective phenomena. Thus, a patient presents himself, complaining of either amblyopia or amaurosis, which is symptomatic of what? A farther interrogation reveals that myopia has been constant from the beginning, or at least the short-sightedness was the first symptom through which the disease was first noticed, and that it increases; that the examination of near and small objects becomes painful, and finally, as the disease becomes more developed, the use of concave glasses is altogether hurtful, and becomes so much so that they have to be thrown aside. Photopsia, photophobia, iridescent vision, circumorbital, and orbital pains, develop themselves as described above, when speaking of acute and chronic choroiditis. What, then, is the nature of this disease? According to Graefe, who had, up to July, 1857, examined over one thousand cases upon the living and dead, it consists of a co-existing inflammation, involving at the same time the sclerotic and the choroid at the posterior portion of the orbit, hence his naming it *posterior* sclero-choroiditis. It might be objected that

[1] Archiv. Ophthal., Graefe, Donders, und Arlt, b. i. s. 390.

the word inflammation is a misnomer, but the hyperæmia of the choroid, the alterations in the pigmentary secretion, the obliteration of the ciliary vessels discovered upon a *post-mortem* examination, the atrophy of the posterior portions of the choroid, the nutritive derangements of the vitreous body, frequently in a state of fluidity, the frequently observed complications of hemorrhages, and finally, the happy results obtained from an antiphlogistic plan of treatment, would, *per exclusionem*, induce us to believe that the disease was of an inflammatory nature.

The complications of the disease are many, the most noted of which is a rupture of the choroidean vessels, producing a sanguineous effusion under the retina. And the writer believes that the extension of inflammation from the sclerotic and choroid has less to do with the consecutive alterations than the effused blood. For, to this effusion, as we have above seen, are referable detachment, hyperæmia, and anæsthesia of the retina, foreign and floating substances in the vitreous body, cataract and other striæ of the lens, and, in a word, all the diseases before mentioned as attacking the various structures of the eye. At the same time he would not pretend to say that all of these complications could not, and are not produced by an extension of inflammation from the affected tissues, as he well knows that such is frequently the case, but he believes the effused *or* extravasated blood to be the principal or chief *casus*.

The ophthalmoscope reveals the pathological conditions upon which the so-called amblyopias and amauroses (to which the disease in question is referable) are dependent, and which are as follows: The bottom of the eye is more or less white, according as the disease is more or less extensive; this white patch is owing to a maceration of the pigmentum: it is irregular in shape, with fringed or ragged borders, if it be of a size greater than the papilla of the optic nerve. This brilliant white patch is the sclerotic made visible by the maceration of the pigmentum of the choroid, and were it not for the vessels seen furrowing the transparent retina, the presence of that membrane would be altogether ignored. These vessels are so marked, so well defined upon the white ground of the sclerotic, that they seem to be enlarged and turgid from a hyperæmic condition; but this is not the case, as they are really so small that they almost become lost upon that portion of the retina, where the choroid remains intact. A very peculiar deception exists in this disease, viz: the appearance as if the white patch were projecting or prominent, whereas in reality it is just the reverse, presenting

a concavity forwards.[1] This condition of affairs is very deceptive, and tends to an incorrect diagnosis: for one readily might mistake a maceration of the pigmentum for a plastic exudation, and *vice versâ*. When the disease first makes its appearance it is with difficulty recognized, as it most frequently appears at the juncture of the choroid and the papilla of the optic nerve, and may be readily confounded with the latter. As the disease advances, the size of the white patch increases, and it is particularly at this stage that it may be confounded with an hypertrophied papilla presenting ragged outlines; but a careful examination displays the normal papilla not being altered in size or appearance, and what was presumed to be a disorganized papilla proves to be the maceration of the pigmentum.

As the disease advances the patch enlarges, the outlines become more fringed and ragged, the anæsthesia of the retina increases, and the general visional functions more deranged. Having sketched posterior sclero-choroiditis as regards its pathology, it would be well to examine it as regards its connection with myopia. The frequency of the disease conjoined with myopia led Graefe to the conclusion, that the latter defect consisted in an enlargement of the antero-posterior axis of the ocular globe; *post-mortem* examinations having always revealed such a condition, and always when myopia and the disease in question were co-existent. Graefe's conclusions were fallacious, and he reasoned by a vicious circle: thus, in certain conditions of a diseased eye myopia exists, the eye in these conditions is lengthened antero posteriorly, therefore myopia depends upon the lengthened axis. Graefe, however, forgot that myopia exists without posterior sclero-choroiditis, and *vice versa;* and, if they can exist separately, they are in no wise absolutely dependent one upon the other. Besides, if posterior sclero-choroiditis be successfully treated, even in the earlier stages, if myopia had previously existed, the cure of the disease does not remedy the defect. From these facts the writer is led to believe that myopia and posterior sclero-choroiditis are frequently complicated and connected, but, that in the present condition of ophthalmoscopical science, it would be extremely difficult to say that one depended

[1] It should be borne in mind that in an ophthalmoscopical examination of the bottom of the eye, all white surfaces or spots appear as if in relief, and all dark or black ones seem to be scooped out or excavated. This condition of affairs is the rule, the reverse is the exception.

upon the other; and, that the remarks made in another part of this paper concerning myopia explains the defect in the only rational manner, as far as observation has been able to determine.

The *Entozoa* as yet met with in the eye are few, and of these only one species has been seen posterior to the lens, or has been discovered by the ophthalmoscope, viz., the *Cysticercus telæ cellulosæ*. The other entozoa which were seen by the naked eye of the observer, were the *Filaria Medinensis* (dranunculus, Guinea worm), a species of entozoa found in the tropical regions of Africa, two cases of which are reported by Dr. Loney, and one by Mongin.[1] In Dr. Loney's cases, the worms were extracted alive from the inner circumference of the cornea, and each measured two inches in length.

Filaria oculi humani.—Dr. Nordman, of Odessa, detected in a lens extracted by Graefe, Sr., two very delicate and small rings, which upon a microscopical examination proved to be filariæ.[2]

Monostoma oculi humani.—Dr. Nordman reports the discovery of eight specimens of this species in an extracted lens.[3]

Distoma oculi humani.—Gescheidt and Ammon found four of these entozoa in an extracted lens.[4]

Echino-coccus homini.—This entozoon has been frequently met with in the areolar tissue surrounding the orbit; but Mr. Bowman[5] relates two cases of its being found within the orbit. Mr. Lawrence, in his excellent treatise on eye diseases, reports one case of its occurring within the ocular globe.

The *Cysticercus telæ cellulosæ* is the entozoon most frequently met with as occurring intra-ocularly. Mackenzie[6] reviews the subject, or rather reiterates the cases of its having been found, A, in the areolar tissue of the eyelids; B, under the conjunctiva; C, in the anterior chamber; and, D, in the cornea.

Graefe,[7] however, was the first to describe the presence of the entozoon within the deep structures, such as in the vitreous body and upon the retina. As to the knowledge of the presence of

[1] Mongin, Journal de Médecine de Paris, 1770; tome xxxii. p. 338.

[2] Mikrographische Beiträge zur Naturgeschichte der wirbellosen. Thiere. Berlin, 1832, H. i. p. 7.

[3] Ibid. H. ii. p. 9.

[4] Zeitschrift für die Ophthalmologie, vol. iii. p. 75. Dresden, 1833.

[5] Medico-Chirurgical Transactions, vol. xvii. p. 48. London, 1831.

[6] Mackenzie, *loc. cit.*

[7] Archiv. Ophthal., *loc. cit.*, t. i. 2te part, p. 343—t. ii. 1te part, p. 263—t. i. 1te part, pp. 452–463.

these entozoa, it does not in the least contribute to the therapeutics of ophthalmology, save in a negative manner, viz., by preventing the use of medicine, and by assuring the patient that all artificial means for the removal of the offending body are perfectly useless. In a purely scientific point of view, the discovery of the presence within the eye of a living animal is in the highest degree interesting, as it involves the various questions of generation.

The rational symptoms presented by the appearance of a cysticercus are not at all conclusive, and are nothing more than what is common to any so called amblyopia.

Ophthalmoscopical examinations indicate the presence of the entozoon in the vitreous body and upon the retina.

A cysticercus of the vitreous body is readily recognized when it is in a state of quiescence, and also when the eye is in a similar condition: it presents the following characteristics: A bluish or greenish-white tumor of a spherical form, obstructing the view of, or at least interfering with the regular position of the retinal vessels. The tumor is formed of a membrane of envelop which constantly surrounds the entozoon, and through which the characteristic form and movements of the cysticercus are readily recognizable. Within the sac enveloping it, the various portions of the entozoon may be distinguished, at least the outlines: thus, in a case seen by the writer at the *klinik* of Graefe, the head seemed adherent to an exuded false membrane within the vitreous, behind which there was a very perceptible narrowing, corresponding to the neck, which was about a line in length. From the base of the neck, the body began to increase, presenting rather a pear-shaped appearance of about three and a half lines in length, of a pearl-gray color, and was folded upon itself rather like the plaits of a shirt bosom.

The complications are always numerous, and may be any one or all of the diseases before described. The most frequent lesion, however, met with as a complication, is a maceration of the pigmentum. Cysticercus of the retina presents the same extra-ocular phenomena as does that of the vitreous body, always being in more exaggerate conditions.

We have thus finished a sketch of the various lesions presented by means of the ophthalmoscope, and although by it this paper is brought to a close, it is by no means so complete as might be desired; for many points of interest have been but glanced at, and others entirely omitted: the general therapeutics indicated in some, and the particular treatment of each left out. Why such has been

the case is readily understood, when we say, that had we given to each particular lesion its proper therapeutical consideration, this essay might have assumed such formidable dimensions, as to be totally devoid of any merit save verbosity. As we merely proposed to consider some of the anomalies as revealed by the ophthalmoscope, it would be inappropriate to say aught more, and having accomplished our task, we make our bow, hoping it has not been a fruitless one.

APPENDIX.

Fig. I. Normal eye, as presented by Desmarres's ophthalmoscope. The subject from whom the figure was drawn is a brunette of a marked type. The figure is magnified one and a half diameters. *A*. Papilla of the optic nerve. *B*. Arteria centralis retinæ. *C* is the accompanying vein (vena centralis retinæ). *D*, *D*, *D*. Spreading out or concavity of the retina, through which the bright shining choroid is visible, as the radiated (folds or deposits) structure of the pigmentum nigrum of the choroid.

Fig. II. Jäger denominates this figure as *amblyopia hæmorrhoidalis* simply. *A*. Optic nerve slightly tinged yellowish. *B*. The spot whence spring the artery and vein, covered by an exudation of plasma. *C*. Extravasations of blood.

In the case seen by the writer, and whose eye presented an almost analogous condition, was a *hyperæmia papillæ* conjoined to chronic choroiditis. In this case, however, there was no exudation covering the origin of the vein and nerve.

Fig. III. Amblyopia of a mild form, in a boy fourteen years of age. Although Jäger denominates the pathological conditions presented by the figure in question as *amblyopia*, it is most undoubtedly the consequence of hyperæmia of the retina and of the papilla, conjoined to a slight choroiditis. The spots upon the papilla being exudations, and the slight deposition of pigmentum above it indicating the derangement of the choroid. *A*. Papilla of the optic nerve, upon which are numerous bluish-gray exudation spots. *B*. The origin of the artery and vein. *C*, *C*. Darker parts of the retina, owing to the deeper color of the choroid: it must be borne in mind that the circumference of all of the figures is as far forward as the *ora serrata*, and that they should present a concavity. *D*. Radiated appearance of the pigmentum, very indistinctly represented, owing to the condition of the parts.

Fig. IV. *Amaurosis (congestiva) completa* of Jäger, chronic, of two years' standing. This figure is given because of the apparent contradiction

in the appearance of pathological conditions, for in the analogous case seen by the writer, the disease was amaurosis from anæmia of the retina. In all probability there had been some congestion previous to the writer's having made any examination, and the presence of the pigment deposits would justify such a supposition. In the writer's case, the vessels were not so large as is represented in the figure. (Vide *anæmia retinæ* in the essay.) *A*. Papilla of the optic nerve. *B*. Spot where the vessels pass in and out. *C*. Deposit of pigmentum: a smaller deposit is seen on the inner side. *D, D*. Radiated arrangement of the pigmentum.

Fig. V. *Amaurosis completa* of Jäger, chronic, of nine months' standing. This is undoubtedly a case of hyperæmia of the retina, in fact a very similar one to that of Fig. IV., as reported by Jäger. The letters point to similar structures, and are the same as in Fig. IV. In the analogous case, as seen by the writer, the structures, as seen by means of the ophthalmoscope, presented evidences of an existing retinitis, chronic in nature, and the remains of what was once a choroiditis of a mild type, the pigment deposits undoubtedly showing such a condition.

Fig. VI. After Jäger, who describes it as "*amaurosis completa* of three months' standing, in a female aged twenty-six years. The retina moderately yellowish-red, the optic nerve uniformly yellowish-white. Upon the central artery, and scattered throughout the substance of the retina, are small, rounded, and oval whitish exudations." This account is but meagre, and did we not know the results of hyperæmia of the papilla and the retina, we would be completely at a loss to know the cause of the amaurosis, which undoubtedly was occasioned by the lesions in question. *A*. Papilla. *B*. Origin of bloodvessels. *C*. Pigment folds. *D*. Exudation spots, the result of a prior inflammation.

Fig. VII. Jäger describes this as a "mild amblyopia, resulting from intoxication in a man forty-five years of age. It was of four weeks' standing, and there was a marked development of vessels, and more or less number of extravasations of a light and dark color, partially enveloping the optic nerve. Yellowish exudations are seen upon the retina at *C*."

Jäger's case was but a mild acute amblyopia; the writer has seen several presenting similar appearances, which were completely amaurotic, being true cases of hyperæmia of the papilla and retina. Instead of there being straw-colored exudations upon the retina there were light-red exudations, apparently formed by arterial extravasations, as at *C* in the figure. This figure was drawn from Jäger, but colored to represent the writer's case. *A*. Papilla of the optic nerve partially surrounded by hypervascular retina. *B*. Venous extravasation. *C*. Arterial extravasation. *D*. Pigment folds.

FIG. VIII. Jäger describes this to be a case of "*amaurosis completa* (of twenty years' standing amblyopia, but five of complete amaurosis). Optic nerve and retina of a uniform orange color. *C*, *C*, *C*, are straw-colored arteries of the choroid. *B*. Black pigment spots about to undergo maceration." The writer has somewhat altered the figure by coloring it to illustrate, almost faithfully, a purely uncomplicated case of choroiditis, which was completely cured by antiphlogistic measures. The case in question presented the symptoms described under the head of choroiditis in the context. Two veins are seen traversing the papilla, which were the only indications of the retina partaking of the affection. The arteries mentioned by Jäger as being straw-colored, were in this instance of the bright-red hue represented in the figure. Numerous streaks of pigment are seen to radiate from the optic nerve, and are very characteristic of the choroid's having been once affected, or is subjected to some alteration at the moment of examination.

FIG. IX. Jäger describes this case as *amaurosis arthritica* (*glaucomatosa*). The writer gives the figure, and colors it to represent as nearly as possible the appearance of the fundus of the membrane of envelop surrounding a *cysticercus* of the papilla. Jäger's description sheds no light upon the case, and the writer would not hazard an opinion as to the true pathological conditions of the eye, as *glaucomatosa* might mean sundry various ones.

It should be borne in mind that none of the figures are colored by Jäger, and that the writer reproduces them almost as an entire new series. Also, it should be remembered that the coloring has not been altogether in accordance with Jäger's descriptions.

FIG. X. Appearances presented by the ophthalmoscope in *albuminuria*.

A. Papilla of the optic nerve slightly tinged with yellow, owing to a deposit of fat globules.

B. Central artery and vein.

b, *b*, *b*, *b*. Pigment spots characteristic of the disease.

FIG. XI. *Hyperæmia papillæ et retinæ.* This case is the one referred to in the context as being one of *spurious color-blindness*. In an uncomplicated case of *hyperæmia retinæ*, there is no network of vessels seen upon the papilla, as in this instance. The two diseases are represented together for two reasons: firstly, because in the case of color-blindness in question they co-existed, and secondly, *hyperæmia papillæ* never exists without *hyperæmia retinæ*. The individual who presented himself, from whose eye the figure was drawn, complained of being unable to distinguish colors by that affected eye (the right); that full greens and red were of a

gray, and all others, with the exception of lemon-yellow, were black; and that such a condition existed but about fifteen minutes after any excitement, such as a full meal, etc. These phenomena are readily explained upon the general principles of vision, and are referable to the turgid condition of the vessels during a state of excitement. The patient had for many years complained of amblyopia of that eye.

A. Papilla covered by a network of vessels.

b, b. New crop of veins developed by the inflammation in question.

c, c. Arteries developed from the same cause.

Fig I.

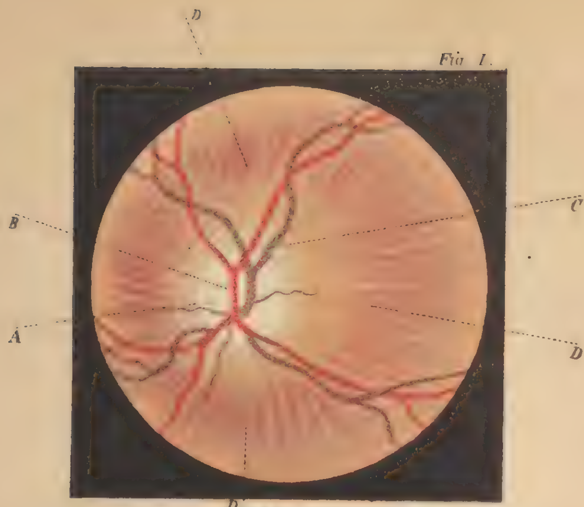


Fig II.

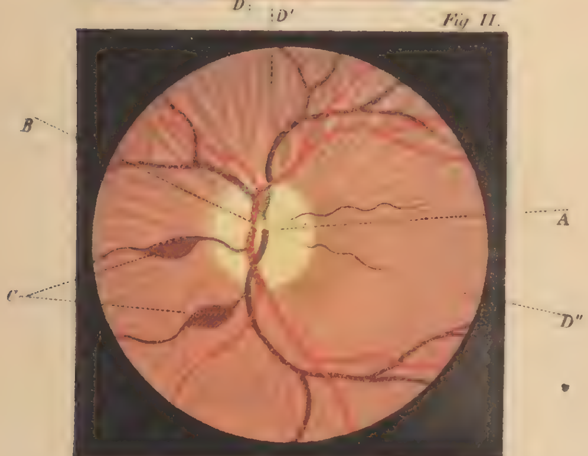


Fig III

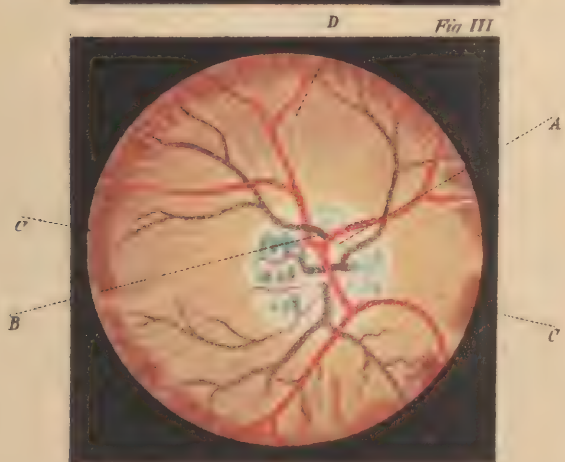


Fig IV.

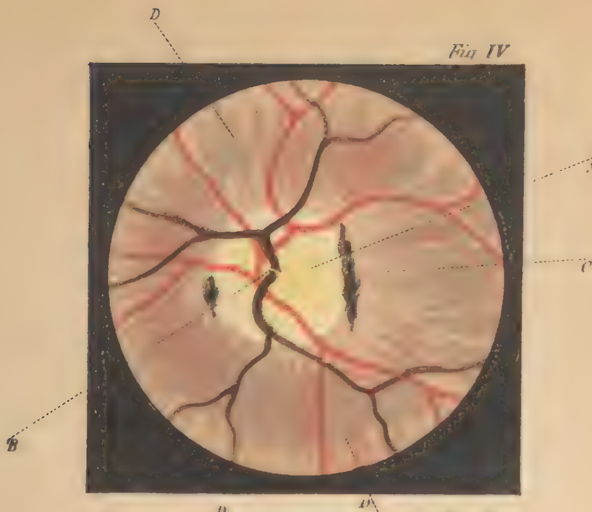
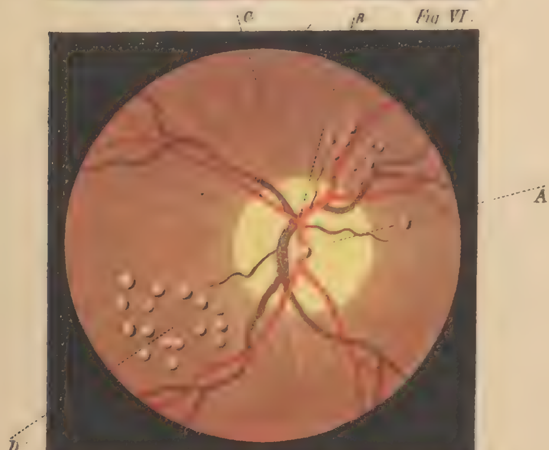


Fig. V.

Fig VI.



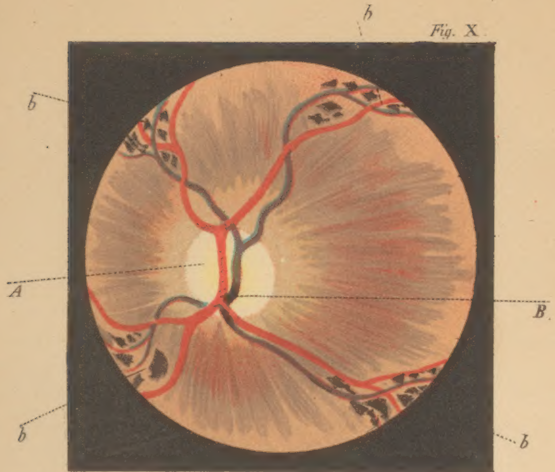
(*Fig. II, III, IV, V, VI, VII, VIII & IX, are after Jäger, but colored and verified by the Writer).*

Fig VII

Fig VIII

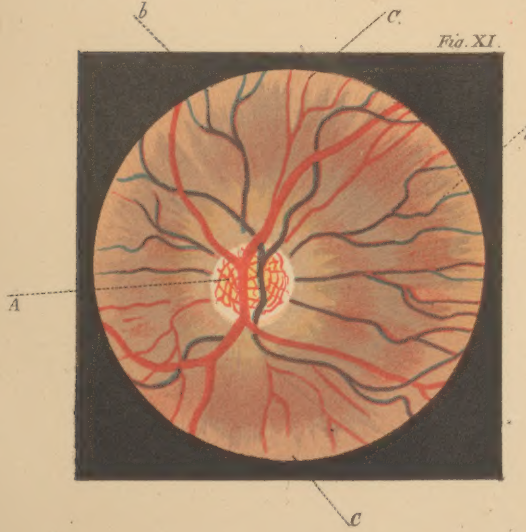
Fig IX

Fig. X.



(Fig. I, X & XI, after nature by the Writer)

Fig. XI.



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